LAKE ONTARIO FISHERIES UNIT

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Vincent G. Kerrio
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1988 ANNUAL REPORT

LAKE ONTARIO FISHERIES UNIT

to the

GREAT LAKES FISHERY COMMISSION'S
LAKE ONTARIO COMMITTEE

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Great Lakes Fisheries Commission
Lake Ontario Fisheries Committee
Buffalo, New York
March 21 - 22, 1989

LAKE ONTARIO FISHERIES UNIT
1988 PROGRAM SUMMARY

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INTRODUCTION

Since March of 1984, LOFU staff have prepared an annual report which summarizes work undertaken during the previous fiscal year[1]. Each annual report consists of a compendium of reports on a variety of subjects. They are intended to keep scientists and managers who work on Lake Ontario informed of our activities, and to promote cooperation and interaction by this diverse group of individuals. Reports are written so as to highlight information of interest to Lake Ontario managers; they are not intended to be substitutes for refereed, journal publications. However, some projects do not produce immediate results, and some tasks do not require reports. The purpose of this report is to tie up any loose ends by summarizing tasks and information not presented elsewhere. This includes:

1. A list of all tasks undertaken including a listing of programs, projects, project leaders, and the recommendations arising as a result of a program review,
2. A report on staff and staff changes at LOFU and in the Lake Ontario Management Committee (LOMC), building renovations and vessel alterations,
3. A discussion of the the status of the Lake Ontario Fisheries Management Plan,
4. A progress report in lake trout early life history studies (fry trapping and habitat mapping),
5. A progress report on a project designed to collect information about incidental catches of sport fish in the eastern Lake Ontario gillnet fishery for yellow perch,

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[1] The 12 month period between April 1 and March 31.

6. A discussion of recent changes in the eastern Lake Ontario commercial fishery,

7. A report on commercial landings in eastern Lake Ontario.

TASKS UNDERTAKEN DURING 1988/89

Seven programs involving 33 projects were conducted during 1988/89. These and associated project leaders are listed in Appendix 1. A variety of special projects were also undertaken during 1988. The following describes how these projects interrelate.

Fisheries Assessment Unit Review

A scientific review of all assessment activity was completed during 1988. The review encompassed all research and assessment projects deemed to be of a monitoring nature. A complete list of the recommendations is presented in Appendix 2. The reviewers recommended increased funding as well as a variety of program changes. Some of the recommendations have already been implemented; others are pending a decision by senior management. The Ministry is currently in the process of making final decisions on the FAU recommendations.

Publications and Committee Work

Periodically the results of the studies listed below culminate in results which are published in scientific journals. A recent list of these is presented in Appendix 3.

From time to time LOFU staff are called upon to serve on committees. A summary of these tasks is presented in Appendix 4.

Commercial Catch Studies

Routine sampling of commercial fish landings was discontinued in January of 1988 in accordance with recommendations made in the assessment review. Annual assessments made with index gillnets in nearshore waters less than 30 meters deep was continued in the Kingston Basin, and three new transects were established in the Eastern Basin (Traverse to Brighton; project A3). This series provides information on a variety of commercial and sport fish species, and on the fish community in these waters. We plan to expand the series westward to Niagara, and to integrate them with past research series if possible. A report is presented by Mathers (see this annual report).

Walleye Stock Assessment

Walleye stock assessment methods were changed so that all tagging occurs in the fall of the year (project B1) rather than in the spring, and a frame study was conducted to permit design of a project which will provide additional information on early life history stages (project

B4). Year class strength is presently indexed by the research trawls (project F1). Index gillnets provide data on walleye distributions (projects A3 and F1). The 1988 creel census in the Bay of Quinte covered all months and seasons (complete creel; projects B2, B3), and provided data on angled harvests of walleye. Beginning in 1989, an index creel will be conducted during May and July only, with a complete creel being conducted every fifth year. The on-board sampling and simulated fishing projects (A1, A2) provided estimates for walleye caught incidentally in the small mesh gillnet fishery for yellow perch. We anticipate discontinuing mark/recapture on a yearly basis after the 1990 field season; age specific population estimates will be made every fifth year thereafter. An age specific harvest management model was developed to aid managers in the evaluation of various management options such as slot limits, season changes or bag limits. See Bowlby and Mathers in this annual report.

Lake Whitefish Assessment

All mark/recapture work on the Lake Ontario whitefish stock was discontinued due to a lack of funds. A limited stock assessment is made using tag ratios and fish tagged in previous years, and from index nets fished in the KIngston Basin (project F3). Tag data are obtained from an examination of commercial landings (project C2). Whitefish from the Bay of Quinte stock are readily captured during the walleye tagging activity, and continue to be processed as a separate part of that project (C1). A special stock identification project (C3) is currently underway which should allow for discrimination between Bay and Lake stocks.

Lake Trout Stock Assessment

Lake trout assessment continues to be guided by the 'Joint Plan For the Rehabilitation of Lake Trout in Lake Ontario'. The plan was prepared by and is utilized by OMNR, NYDEC and the USFWS. Indices of relative abundance, survival rates etc. are calculated using data collected through a cooperative, multi-agency index project (E5). Lake trout sport harvests are estimated in the western basin creel projects (E2, E3, and E5). Although no creel was conducted in the Kingston Basin during 1988, sport harvests of lake trout appear to continue to increase. Commercial harvests are estimated using data collected in the commercial fish assessment program (A1 and A2). DEC, OMNR, DFO and the University of Cornell cooperated in a spring fry trap study at Stoney, Yorkshire and Charity shoals (project E6). A variety of data on lamprey attack rates continue to be collected (projects D1, D2 D3; see Jolliff et al. in this annual report). A complete analysis is presented in Schneider et al. (see this annual report). A separate study of spawning adults was conducted by Dr. John Casselman (project F2).

Assessment of Stocked Salmonids

A variety of census techniques continue to be employed to determine attributes of salmonid harvests, including access creels, trailer counts and charterboat questionnaires (projects E2, E3 and E4). Spawning runs of Coho and Chinook continue to be monitored during the fall egg taking (project D1).

STAFF AND FACILITY CHANGES

February 6, 1989 marked the third anniversary of LOFU's relocation to temporary quarters at Picton Heights. During the intervening three years, the fisheries station at Glenora has been completely renovated and expanded. The move and renovations were necessitated by the discovery of large amounts of bat excrement and a possible problem with histoplasmosis.

Numerous organizational and staff changes have also occurred during this period. The former assessment unit and research unit have been reorganized and integrated into a single entity called the Lake Ontario Fisheries Unit, or LOFU. In this new unit, all technical and support staff form part of a technical pool, and all operational activities are carried out under the leadership of an Operations Supervisor. Garry Himburg was LOFU's first Operational Supervisor.

Some notable staff changes have recently occurred. Garry Himburg left to become Fish and Wildlife Supervisor at Napanee. Mr. W. Jack Christie, the former senior scientist became Great Lakes Research Coordinator and Dr. John Casselman was appointed senior scientist. A permanent staff biologist position was funded at Richmond Hill using angler license funds. Tom Stewart was appointed to this position. A list of staff employed at LOFU appears in Appendix 5.

LAKE ONTARIO FISHERIES MANAGEMENT PLAN[2]

On July 3, 1986 a three-man planning subcommittee was created by the Lake Ontario Management Committee to develop a Lake Ontario Fisheries Management Plan. It was decided that the Lake Ontario Plan would be consistent with the provincial planning guidelines for District Fisheries Management Plans (DFMP) and would progress in concert with the plans of the five districts bordering Lake Ontario. For most districts bordering the lake, audio visual presentations, fact sheets and questionnaires relating to Lake Ontario were presented at two rounds of public consultation meetings. A draft of the Lake Ontario Plan is currently on hold pending district completion and approval of their final DFMP's. The extension of commercial fisheries modernization initiatives in eastern Lake Ontario has also caused planning delays. A Lake Ontario plan is anticipated by the end of 1989.

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2. Prepared by P. Savoie and R. L. Desjardin, Richmond Hill

LAKE TROUT FRY TRAPPING

During April and May of 1988, fry traps were placed at Charity Shoal, Yorkshire Bar and Stoney Island. The work was a cooperative venture involving staff from OMNR, the New York State Dept. of Environmental Conservation (NYDEC) and Cornell University. Fry were captured at Stoney Island as is reported by Schneider et al. elsewhere in this annual report. Fry were not captured at the other shoals. In order to prepare for the 1989 field season, Dr. John Fitzsimmons arranged to have detailed maps of the shoal prepared by cartographers from the Canada Center for Inland Waters, Fisheries and Oceans Canada. Extensive diving revealed that the suitable substrate constituted a narrow band a few meters wide by a couple of hundred meters in length. It seems quite unlikely that more than a few traps would have been placed on the best substrate by the grid of traps placed on the shoal during the spring of 1988. The fry trapping operation will be repeated in the spring of 1989. The traps will be deployed and serviced by divers to insure that they are correctly situated.

SIMULATING THE EASTERN LAKE ONTARIO COMMERCIAL FISHERY FOR YELLOW PERCH[3]

Small mesh gillnet was fished by Lake Ontario Fisheries Unit staff in Adolphus Reach and the North Channel during April and September, in the North Channel during May and in Prince Edward Bay during July in 1988. The study provided independent estimates of incidental catch of sport fish in the yellow perch gillnet commercial fishery. The project used the same type of gear, techniques and fishing locations used by the commercial fishery. A total of 14,387 fish weighing 1,695 kg. were captured. Sport fish made up between 9% and 26% of the catch. Comparisons with samples taken directly from the commercial fishery suggest that better quantified estimates of the incidental catch of sport fish can be obtained through an on-board sampling project. A file report is expected to be completed during the first half of 1989.

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[3] Prepared by William Dentry and Jim Boraski, OMNR Picton

CHANGES IN THE EASTERN LAKE ONTARIO COMMERCIAL FISHERY 1988/89[4]

Background

At the beginning of 1988, 160 commercial fishing licenses for hoopnets, hooklines, trapnets and gillnets were held by 95 commercial fishermen. Fifty-six gillnet licenses were issued to 59 of those commercial fishermen, with 264,000 meters of gillnet licensed for the open waters of Lake Ontario, Adolphus Reach and the North Channel.

In 1988, the total harvest of 1,190,000 pounds of fish of all species had a landed value of $897 thousand. The landed value of commercial harvest in gillnets was approximately one-half of the total landed value of the overall commercial fishery. The most valuable fish species harvested in gillnets are yellow perch, whitefish and white perch.

Problems of Incidental Catch in the Gillnet Fishery

Licensed commercial gillnet fishermen on Lake Ontario target fish species such as yellow perch, white perch, whitefish and smelt. Other fish species for which commercial fishermen are not presently licensed, such as trout and walleye, are also inadvertently caught in gillnets, resulting in what is called an "incidental catch". The incidental catch of non-target fish species in the commercial gillnet fishery has become a major concern in recent years. Incidental catch has the potential to significantly impact on the progress of fisheries rehabilitation and on the achievement of overall fisheries management objectives for Lake Ontario.

1989 May/June Study by MNR

Complaints by local commercial fishermen and observations by MNR staff have indicated substantial incidental catches of non-target fish species in small mesh gillnets. During May and June of 1987, MNR initiated a study to determine levels of incidental catch of non-target fish species in the small mesh yellow perch gillnet fishery. The results of the MNR netting studies were extrapolated to derive total catch estimates for the actual commercial gillnet fishery during May and June of 1987.

Overall, 30 percent of the weight of the estimated May/June commercial gillnet catch was sport fish, while approximately 39 percent was yellow perch, the target species.

Index netting conducted by the Lake Ontario Fisheries Unit, field observations of actual commercial fishing operations and reports by individual commercial fishermen indicate that incidental catch is a problem at other times of the year. As the water warms in the North Channel in late may, immature walleye move out of the Bay of Quinte and remain vulnerable to small mesh gillnets until late summer. Young walleye have also created incidental catch problems for the Brighton gillnet fishery. The fall gillnet fishery off Brighton has been subject to high incidental catch of lake trout. The October portion of the 1987 fall gillnet fishery for whitefish off the south shore of Prince Edward County encountered serious incidental catch problems, involving trout, walleye and smallmouth bass.

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[4] Prepared by P. A. Smith, District Manager, Napanee 1989.01.13

Public Consultation

Early in 1988, the Ministry of Natural Resources initiated public discussion on the subject of incidental catch in the Eastern Lake Ontario gillnet fishery.

Background information on incidental catch was reviewed with representatives of local interest groups and spokesmen for the Ontario Fish Producer's Association and the Ontario Federation of Anglers and Hunters.

The public was asked to consider and comment on a list of possible management options for dealing with incidental catch in Eastern Lake Ontario and was asked to suggest other alternatives for dealing with this problem.

Changes in Management of the Ontario Commercial Fishery

After consideration of relevant background information and public input, major changes were initiated in the management of commercial fisheries in Eastern Lake Ontario. The new program announced on March 30, 1988 included timing restrictions on gillnet operations, commercial trapnet harvest of walleye on an experimental basis, and a buy-out program to retire gillnet operations offered for sale.

These new measures are intended to reduce incidental catch of lake trout, immature walleye, and game fish, such as smallmouth bass, in the Eastern Lake Ontario commercial gillnet fishery.

Beginning in 1988 gillnets are prohibited in the following time periods and areas:

- Quota Area 1 (off Brighton) from May 1 to July 31;
- Quota Area 2 (eastern basin of Lake Ontario) from May 1 to June 30;
- Quota Area 4 (the North Channel near Kingston) from May 1 to August 31

Good compliance was demonstrated by the commercial fishing industry during these closed periods. In 1988, MNR staff closely monitored incidental catches of non-target species in ongoing gillnet operations conducted during the designated open seasons. Most commercial fishermen cooperated well with MNR on-board sampling programs (Report of study results contained elsewhere in LOFU 1988 Annual Report).

In 1989 a small quantity of walleye will be allocated to those commercial fishermen using licensed entrapment gear in the open waters of Lake Ontario, exclusive of the Bay of Quinte and the North Channel. This experimental commercial allocation of 30,000 lb. of walleye will be subject to specific permit conditions, including:

- only live capture gear will be permitted
- fishing will be restricted to a narrow time period during the spring
- the size of walleye taken will be closely regulated through specific slot-size limits, to ensure that primarily walleye from strong year classes are harvested and that commercially harvested walleye are within acceptable contaminant limits established for safe human consumption

To promote greater experimentation using live capture gear and to encourage gillnet fishermen to convert to trapnets, quota and season adjustments were considered for species such as eel and whitefish. Several commercial fishermen have realigned quotas and negotiated longer fishing seasons for impounding gear licenses.

For those commercial fishermen wishing to dispose of gillnet licenses or to retire form the fishery, a buy-out program was initiated to purchase gillnet operations offered for sale during 1988.

The buy-out program, which is now completed, involved the purchase of 20 of the 56 gillnet licenses on Eastern Lake Ontario. The quantity of licensed gillnet was reduced by 85,250 meters or approximately 32 percent. Four new trapnet licenses were issued to commercial fishermen who wished to convert to gillnet licenses to entrapment gear.

By limiting gillnets to those months when incidental catch is low, by experimenting with trapnet harvests of walleye, and through greater flexibility in seasons and quotas for impounding gear fisheries, commercial fishermen are being assisted in moving toward a restructured fishery on Eastern lake Ontario.

COMMERCIAL LANDINGS IN NAPANEE DISTRICT[5]

During the 1988 calendar year, the commercial fishermen reported harvesting a total of 1,190,436 pounds (round weight) of fish as shown below.

Species	1988 Landings	Price per lb.	1988 Value
Bullheads	329,913	0.50	$164,957
Carp	79,034	0.37	29,243
Catfish	18,554	0.26	4,824
Crappies	15,193	1.50	22,790
Eels	194,012	1.00	194,012
Drum	8,297	0.15	1,245
Lake Herring	13,413	0.43	5,768
Lake Whitefish	85,276	1.12	95,509
Menominee	130	0.85	111
Rock Bass	25,948	0.29	7,525
Smelt	20	1.00	20
Sunfish	58,888	0.45	26,500
Suckers	23,248	0.20	4,650
White Bass	1,472	0.52	765
White Perch	61,996	0.37	22,939
Yellow Perch	268,778	1.17	314,470
Dogfish	6,264	0.20	1,253

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5. Prepared by Dave Montgomery, Fisheries Management Officer, Napanee District

APPENDIX 1. Programs conducted by the Lake Ontario Fisheries Unit between April 1, 1988 and April 1, 1989.

A. Commercial Fish Assessment Program

Project A1. On-board sampling of the small mesh gill net fishery for yellow perch.
Project leader: William Dentry
Project A2. Simulating the small mesh gillnet fishery for yellow perch.
Project leader: William Dentry
Project A3. Index gillnetting.
Project leader: Alastair Mathers

B. Walleye Stock Assessment Program.

Project B1. Fall mark-recapture project.
Project leader: James Bowlby
Project B2. Bay of Quinte summer creel census.
Project leader: Alastair Mathers
Project B3. Bay of Quinte winter creel census.
Project leader: Alastair Mathers
Project B4. YOY Outboard trawling.
Project leader: James Bowlby

C. Lake Whitefish Stock Assessment Program

Project C1. Fall tagging in the Bay of Quinte.
Project leader: James Bowlby
Project C2. On-shore sampling project.
Project leader: James Bowlby
Project C3. Stock Identification Study.
Project leader: Dr. John Casselman

D. Lamprey Monitoring Program

Project D1. Coho and chinook Spawning Runs.
Project leader: Tom Stewart
Project D2. Derby monitoring.
Project leader: Tom Stewart
Project D3. Research index netting.
Project leader: Dr. John Casselman

E. Salmonid Assessment Program.

Project E1. Western Basin trailer counts
Project leader: Tom Stewart
Project E2. Western lake ontario access creel survey
Project leader: Tom Stewart
Project E3. Charter boat questionnaire
Project leader: Tom Stewart

Project E4. A cooperative (DEC/OMNR/FWS) index gillnet fishery for adult lake trout
Project leader: William Dentry
Project E5. Lake trout fry traps.
Project leader: William Dentry
Project E6. Smelt trawling (DEC/OMNR/FWS)
Project leader: Tom Stewart

F. Research Program

Project F1. Bay of Quinte gillnet and trawl series.
Project leader: Dr. Don Hurley
Project F2. Lake trout spawning shoal studies.
Project leader: Dr. John Casselman
Project F3. Kingston Basin Index Gillnet and Trawl Series.
Project leader: Dr. John Casselman
Project F4. Alewife, Yellow Perch and White Perch Diet Studies.
Project leader: Dr. Don Hurley
Project F5. Smallmouth Bass Investigations in Algonquin Park.
Project leaders: Dr. Mark Ridgway and
Dr. Brian Shuter
Project F6. Gillnet selectivity in White Perch.
Project leaders: Dr. Don Hurley and
Dr. Mark Ridgway

G. Community Oriented Lake Assessment (COLA) Program

Project G1. Vessel evaluation and preparation.
Project G2. Exploratory bottom and midwater gillnet sets.
Project G3. Exploratory bottom and midwater trawling.
Project G4. Scanmar trawl evaluation.
Project G5. Smelt bottom trawling.
Project leader: Ted Schaner (G1-G5)

H. Special Projects:

H1. Data synthesis, Smelt trawling 1981 to 1988.
Project leaders: Tom Stewart and Ted Schaner
H2. Data synthesis, Coho spawning runs, 1977 to 1988.
Project leader: Tom Stewart
H3. Bay of Quinte Remedial Action Plan
Project leader: Dr. Don Hurley

APPENDIX 2. Recommendations made by LGL in the 1988 FAU review

R1. P9: LOFU's geographic mandate be clearly defined but sufficiently broad so it does not impose any additional constraints on current or future assessment activities for Lake Ontario stock.

R2. P10: The Lake Ontario Fisheries Unit and district staff work together to identify the stocks and fisheries that are not covered by existing or proposed assessment programs and with the aid of senior OMNR staff, allocate responsibilities and assessment funds to the appropriate group.

R3. P16: LOFU document the biases and determine the precision associated with CPE and bio-sampling data obtained through the current commercial catch sampling program.

R4. P17: OMNR seriously consider collecting the biological samples and incidental catch data they need to manage the Lake Ontario's commercial fisheries from a cooperative fishing or index netting program.

R5. P22: LOFU ensure that all future incidental catch estimation reports include data summaries, catch estimates for each time and area strata, and justification for any extrapolations used in the analysis.

R6. P23: the results of the 1987 Simulated Commercial Fishing Program not be extrapolated to commercial fisheries or fishing seasons other than the 1987 spring commercial perch fishery.

R7. P23: if simulated fishing programs are to be conducted in the future, efforts be made to collect data on how catch rates change with depth for each major commercial gillnet fishery.

R8. P23: LOFU staff carefully examine the difference between simulated fishing in 1987 and commercial fishing in 1987.

R9. P27: LOFU expand its western basin creel survey program to collect information on the CPE for charter boat anglers and the effort and CPE for anglers that moor their boats at marinas through on-water sampling; and

R10. P27: LOFU conduct aerial surveys to determine total fishing effort and expand the survey to obtain samples from each fishing area throughout the season.

R11. P30: LOFU conduct more angler interviews in the Bay of Quinte in order to improve the precision and accuracy of the walleye harvest estimates.

R12. P30: Fork length and scale samples be obtained from a stratified sample of all the walleye observed during creel surveys.

R13. P31: LOFU limit creel surveys in the eastern basin to one every 2 - 3 years; and

R14. P32: creel survey effort should be reallocated to maximize the number of angler interviews at each of the sites surveyed in 1987.

R15. P32: LOFU use the results of the on-water survey program to design a similar survey for the western basin where information on the relative amount of fishing effort by launched, moored and charter boats is needed and the expenditure better justified.

R16. P34: electrofishing be used to help establish or evaluate a YOY index fishing program based on more traditional and cost effective methods.

R17. P34: LOFU conduct a detailed assessment of the suitability of the various research trawl stations as an index of YOY walleye.

R18. P37: LOFU determine whether research fishing needs to be conducted at all six sites in the eastern basin; and

R19. P37: LOFU evaluate the limitations of the current research gillnet program in light of the findings from recent depth-stratified assessment gillnetting in the eastern basin.

R20. P40: OMNR support the new assessment gillnet fishing program in the eastern basin for at least another five years;

R21. P40: LOFU determine the feasibility of initiating additional depth-stratified index gillnetting and trawling in the central and western basins as part of COLA.

R22. P43: LOFU address COLA's objectives through a structured analysis of the available data, before attempting to design any new data collection programs.

R23. P44: the COLA program be used to coordinate new and existing index fishing programs and related analyses.

R24. P55: Use an age-stratified Jolly-Seber population estimation procedure.

R25. P55: Examine the marking rates of walleye in light of the more demanding data requirements of the age-stratified procedure. The mark-recapture program may need expansion.

R26. P55: Develop a relationship between YOY and partially vulnerable fish.

R27. P55: Develop a selectivity curve by age class for trapnets. Similarly, the selectivity of anglers for walleye by age class should be determined.

R28. P55: Examine the historical age-growth data carefully for evidence of density changes in growth and maturity, and incorporate these changes into the simulation model. The model should also account for size-dependent changes in cannibalism rates. These changes can lead to catastrophic shifts in stock size from high productive levels to a lower "equilibrium" where stock recovery is impaired by high rates of cannibalism.

R29. P55: Review historical data so as to find the best available index of long term abundance changes and use this with the catch data to fit the Deriso-Schnute model (Deriso 1980, Schnute 1985) to the historical pattern. The key thing to look for in this analysis is a dome shaped stock-recruitment relationship that implies risk of a catastrophic shift as noted in point (5).

R30. P55: Develop objective criteria for the assessment of optimum exploitation, based on stock recruitment or risk analysis.

R31. P58: Mark all hatchery produced fish with CWT or other non-visable and inert tag (e.g., rare earth elements) so that the contribution and survival of stocked fish and wild fish (by subtraction) can be calculated with a high degree of accuracy and precision.

R32. P58: The index of juvenile abundance should receive more emphasis as a monitoring tool. The ability to distinguish between wild and hatchery fish (as in point) must be a critical aspect of the trawl program.

R33. P62: Use the Jolly-Seber estimation procedure (the marking effort will probably require expansion to obtain the necessary sample size).

R34. P62: Review the catch-per-effort data, possible corrections for gear improvements and effort response by the fishermen to quota size with the view of developing an index of long term abundance changes; use this with the catch data to fit the Deriso-Schnute model (Deriso 1980, Schnute 1985) to the historical pattern (a possible alternative assessment technique).

R35. P62: Develop objective criteria for the assessment of optimum exploitation rate, based on stock-recruitment or risk analysis.

R36. P62: LOFU should initiate the application of objective stock assessment procedures to yellow perch.

R37. P65: OMNR's district offices be allocated the responsibility for assessing local stocks and sport fisheries that are based on these species.

R38. P71: past and future creel survey and other stock assessment data be analyzed to provide information useful for assessments of predator abundance.

R39. P71: effort be directed toward the development, evaluation and application of approaches for the assessment of salmonid distributions, and if possible, feeding habits during their period of lake residence.

R40. P72: a bottom and mid-water trawl program be implemented, and that the collections are calibrated to the extent possible against existing surveys in both the U.S. and Canada, such that comparisons of historical and future assessments are possible.

R41. P72: otoliths and fin rays be used to age alewife and smelt, respectively, in future forage assessment.

R42. P72: predator diet studies be continued, and that wherever possible collections of predators for stomach contents analysis be combined with surveys of forage species relative abundance, in the habitats utilized by predators.

R43. P73: OMNR continue to support, and if possible, expand its cooperative relationship with U.S. agencies with respect to forage assessment activities.

R44. P79: The current assessment at the eel ladder be continued to provide a relative index of upstream migration.

R45. P79: OMNR examines the feasibility of a study that could determine the relative contribution of the eel ladder and lock system to the total eel immigration into Lake Ontario.

R46. P79: OMNR include assessments of eels as a prey and predator species in any future programs designed to quantify predator-prey interactions in Lake Ontario.

R47. P82: this portion of LOFU's budget be reallocated to analyses of existing data, expansion of index fishing and simulated commercial fishing programs, and the design of OMNR-OFPA cooperative fishing programs for specific commercial fisheries.

R48. P84: fisheries managers, angler groups and commercial fishermen assist and support the Lake Ontario Fisheries Unit in their efforts: 1) to improve the efficiency of current catch monitoring programs; and 2) to allocate a larger portion of their resources to collecting and analyzing the data needed for stock and fish community assessments.

APPENDIX 3. Research papers published by LOFU staff during 1988.

MINNS, C. K. and D. H. HURLEY. 1988. Effects of net length and set time on fish catches in gillnets. North Am. J. Fish. Mgt. 8:216-233.

BOWLBY, J.N. and J.G. IMHOFF. 1988. Alternatives in predicting trout biomass in streams. *In* Gore, J.A. and G.Petts. Alternatives in regulated river management. CRC Press, Inc. Chapter 13, in press.

BOWLBY, J.N. and J.M. GUNN. 1988. Metals in stocked lake trout (*Salvelinus namaycush*) in lakes near Sudbury, Canada. Water, Air, and Soil Pollution 39:217-230.

RIDGWAY, M.S., D.A. HURLEY, AND K.A.SCOTT. 1988. Temperature, predation and the abundance of alewife in the Bay of Quinte, Lake Ontario. J. Great Lakes Res. *in press*.

APPENDIX 4. Committee work involving LOFU staff.

	Committee	Person
1.	GLFC Walleye Rehabilitation Workshop C. Lewis and P. Colby, co-chairmen	J. Bowlby
2.	Walleye Modeling Workshop (to investigate slot limits etc) C. Lewis chairman	
3.	COLA steering committee co-chairman	Wm. Dentry
4.	Predator Biomass working group Jim MacLean Chairman	
5.	Lake Ontario Stocking Committee (chairman S. Kerr)	
6.	Scientific support for the BQ RAP Workshop	A. Mathers
7.	Lake Trout Synthesis working group (re developing sampling methodology)	T. Schaner
8.	COLA technical Committee, Ted Schaner chairman	
9.	Lake Trout Synthesis working group (re population dynamics subgroup)	T. Stewart
10.	Atlantic Salmon Advisory Group (Ron Desjardin, chairman)	

APPENDIX 5. LOFU staff in 1989.

OMNR Staff at LOFU

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Dr. John Casselman, Sr. Scientist
Dr. Don Hurley, Scientist
Dr. Mark Ridgway, Scientist
W. Jack Christie, Great Lakes Research Coordinator
Dr. Peter Sly, Visiting Scientist (Canada Centre for Inland Waters)
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William Dentry, FAU Supervisor
Ted Schaner, FAU Biologist
Alastair Mathers, FAU Biologist
Jim Bowlby, FAU Biologist

Ken Scott, Computer Systems and Database Manager
Kelly Garbutt, Data Entry

Jeff Church, Age Determination Technician

Chuck Wood, Senior Technician
Wayne Miller, Senior Technician
Dale Dewey, Technician
Steve Lawrence, Technician
Tom Lawrence, Technician
Joe Dibbits, Technician
Tim Shannon, Technician
Jim Boraski, Technician
Dawn Walsh, Technician

John Kinney, Administrative Clerk
Carol Ward, Receptionist and Secretary
Linda Corbett, Secretarial Support

Al MacIntosh, Captain RV Namaycush
Peter Klaassen, Captain RV Steelcraft

LOFU Staff at Richmond Hill

Tom Stewart, FAU Biologist
Paul Savoie, Fisheries Management Planning
Monica Klymiuk, Experience Student
Ann Samiec, Fisheries Technician
Doug Oliver, Biologist

Great Lakes Fishery Commission
Lake Ontario Committee Meeting
March 21-22, 1989
Buffalo, New York

BAY OF QUINTE ANGLING SURVEYS, 1988

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ABSTRACT

Angling surveys were conducted on the ice fishery (January and February) and the open water fishery (May to November) during 1988. The angling effort (497,078 angler hours) and the walleye harvest (114,337 fish) estimates for the open water fishery suggested that this segment of the fishery has stabilized relative to other recent estimates. The angling effort estimated for the ice fishery (194,112 rod hours) suggested that the fishery was of a similar size to that observed in 1986. However, the anglers' harvest of walleye (7,416 fish) was much lower than that estimated in previous ice fishing surveys.

The fish harvested by anglers during the ice fishery were from a wide variety of age groups. The older age groups comprised a much larger proportion of the harvest than during the open water fishery which is dominated by the younger age groups (primarily 2, 3 and 4 years old).

The outlook for the Bay of Quinte walleye angling fishery in near future is good because of the strong 1985, 1986, and 1987 walleye classes. The potential influences on the harvest of walleye of changing the daily bag limit, and establishing a minimum size limit are discussed.

RECOMMENDATIONS

1. Peak months of angling activity (May and July) should be monitored annually. An extensive open water angling survey (May to November) should not be necessary for several years since the angling effort (10% of open water total) and walleye harvest (4% of the open water total) during the fall season are relatively small.

2. Future winter angling surveys should include the Long Reach area because angling effort in this area has increased in recent years.

INTRODUCTION

Angling surveys have been conducted on the Bay of Quinte periodically since 1957. These surveys have all shown that the most abundant fish species caught in the sports fishery is the walleye. Over time the angler effort and walleye catches have changed dramatically with the fluctuations in the walleye population. Christie (1958) and Watson (1964) provide summaries of earlier angling surveys. Recent surveys have been summarized by Muldoon (1982) and Schaner (1986). This document describes the surveys conducted during the 1988 ice fishery and open water fishery on the Bay of Quinte and provides comparative data from previous surveys.

The Bay of Quinte walleye fishery usually consists of an ice fishery during January and February and an open water fishery from May until freeze-up (usually late-December). The fishery is closed in March and April to protect spawning walleye. The walleye harvest during the ice fishery is generally ten percent of the open water harvest. Angling effort during the ice fishery is approximately twenty-five percent of the open water level.

The following are some of the current regulations which influenced the catch of walleye during the fishery in 1988:

(i) Anglers were allowed one line during the open water fishery and two lines during the ice fishery.

(ii) The daily catch limit was four fish.

(iii) There was no restriction on the size of the walleye which could be legally harvested.

METHODS

The angling surveys were conducted to obtain information on angling effort, catch and harvest, socioeconomic characteristics on the anglers, and biological attributes of the anglers' harvest. These surveys were not designed to provide an index of walleye abundance.

The basic design of these surveys and subsequent data analysis were carried out using CREESYS (Lester and Trippel 1985). The angling surveys were stratified by space, day-type (weekends and weekdays), and season to reduce the variance of the angling effort and harvest estimates. These angling surveys covered the Bay of Quinte from Trenton to Glenora and included 12 geographic strata (Figure 1).

The surveys combined angling activity counts with interviews conducted with anglers on the water. During the open water fishery aerial boat counts were conducted during May and June when angling pressure was expected to be high enough to make counting on the water inefficient. During other times boat counts were conducted on the water. In the winter this design was adopted because poor weather and ice conditions often made it difficult to collect activity count data.

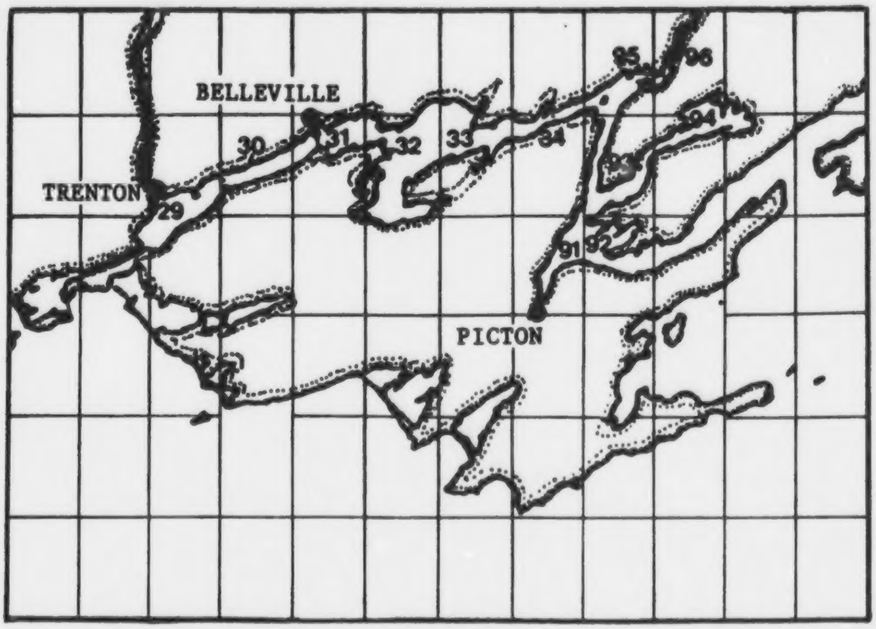

Figure 1. The Bay of Quinte showing the twelve areas used in the 1988 ice fishing survey. The following names are used in reference to these areas: 29-Trenton, 30-Maketewis Island, 31-Belleville, 32-Point Anne, 33-Trident Pt., 34-Telegraph Narrows, 95-Deseronto, 96-Napanee River, 93-Long Reach, 94-Hay Bay, 92-Baggot's Bay, 91-Picton Bay.

Ice Fishery

The ice fishing survey was conducted from January 4 to February 28, 1988 and this whole time period was considered to be one season. Day-types were stratified into weekend days and week days. All angling was assumed to be conducted between 0700 and 1700 hours.

Angling party interviews and hut occupancy checks were conducted in only some of the areas (29, 30, 31, 32, 34 and 95) and the catch and harvest rates were assumed to apply to all the areas with count information. The areas where the interviews were taken were those with the highest angling activity and the safest ice conditions. Angling survey clerks conducted roving interviews and estimates of fish catch and harvest rates were calculated from these data. Also, fish huts were checked to determine occupancy rates. During the interviews fork lengths were measured from the fish harvested by the anglers. Age composition of the walleye harvested was estimated using a fork length - age key calculated using using data from the fall 1987 trapnetting project.

Aerial counts of fish huts and individual anglers on the open ice were conducted in each of the areas. Fishing pressure was measured using aerial counts which were scheduled evenly across day-types, time periods, and geographic areas. Two flights were scheduled for each week - one during the weekend and one during the week.

Open Water Fishery

The open water angling survey was conducted from May 7, 1988, the opening day of the walleye season, until November 30, 1988. This time period was divided into six seasons:

a. 'Opening Weekend' - May 7 and 8
b. 'Rest of May' - May 9 to 31
c. 'June'
d. 'July'
e. 'August'
f. 'Fall' - September, October, November

Day-types were stratified into workdays and non-workdays.

Angling survey clerks conducted roving interviews on the water during both week days and weekend days. During the interviews fork lengths were measured and scale samples taken from the walleye harvested by anglers. Scale samples were not collected on weekend days during May, June, and July to ease the technicians work load.

Fishing pressure was measured using aerial boat counts or 'on water' boat counts conducted evenly across day-types and time periods. Eight aerial survey flights were conducted during the opening weekend season while twenty flights were conducted in the rest of May, and twenty in June. During the other seasons of the open water survey boat counts were made on the water.

RESULTS

Ice Fishery - Angling Effort

We estimated that the angler effort for the 1988 ice fishery (January 4 to February 28) was 194,112 rod-hours (154,617 angler hours). Forty-nine percent of this effort was attributed to anglers in huts, fifty-one percent to anglers on the ice. This level of angling activity is similar to that determined for the 1986 winter ice fishery (Table 1, Figure 2).

Geographic differences in angling activity were evident. Trenton had by far highest numbers of fishing huts counted during the survey (Figure 1). Large numbers of huts were also observed near Maketewis Island, Belleville, Big Bay, and Trident Point. The highest counts of 'on ice' anglers were observed at Big Bay and Trident Point.

Table 1. Estimated angling effort (rod hours) in the Bay of Quinte fishery, 1981 to 1988. Estimates are given for each angling season including the opening weekend (Opening) and the winter ice fishery (Jan. and Feb.). No data available for 1983.

Angling Season	Year 1981	1982	1984	1985	1986	1987	1988
Jan. Feb.	-	95033	128117	-	170737	-	194112
Opening	-	-	47237	43959	49593	90113	90973
May[a]	97119	144163	180511[e]	162162	253340	290225	233524
June	62336	57126	-	58093	51949	81203	54222
July	68401	71201	96607[b]	94711[b]	83075	82346[d]	95105
Aug.	58505	70898	83127[b]	81495[b]	101738	137428[b]	63662
Sept.	19426	25307	26960[b]	26431[b]	36635[b]	44571[b]	
Oct.	9207	7572	13480[b]	13215[b]	18317[b]	22286[b]	50566[f]
Nov.	4704	6039	6740[b]	6608[b]	9159[b]	11143[b]	
Dec.	0[c]	0[c]	0[c]	0[c]	0[c]	0[c]	0[c]
Open water Totals	319401	382306	451581	442717	554213	669202	497079
Annual Totals	-	477339	579698	-	724950	-	691191

[a] May data include the opening weekend data.

[b] Estimated based on current year's May and June total and the trend through season from 1981.

[c] Fishing effort in December remains unquantified but is considered negligible.

[d] The July 1987 estimate is extrapolated from data from July 1 to July 15, 1987.

[e] Separate May and June estimates for 1984 are not available.

[f] During 1988 September, October, and November were considered to be one season.

Previous ice fishing surveys have not included the areas of the Bay below Deseronto because fishing effort was considered to be insignificant. During this survey little or no angling activity was observed at the Napanee River, Hay Bay, Picton Bay, and Glenora. The Long Reach area (in particular Sherman's Point), on the other hand, was observed to have counts of up to 43 'on ice' anglers, and up to 27 fish huts. No angler interviews were conducted at this location. Future surveys should include interviews at Long Reach.

Ice Fishery - Catch and Harvest

Three species of fish (walleye, yellow perch and northern pike) were caught during the ice fishery (Appendix 1). The walleye harvest (7,416 fish) during 1988 was much lower than 1986 (23,768 fish) (Table 2). Low walleye catch rates were found in all the sampled areas. The reason for the decline in the walleye catch and harvest is not known - however, the very high numbers of young-of-the-year gizzard shad reported in the bay may have had an influence. The harvest of yellow perch was estimated at 39,914 fish - a dramatic increase over the estimated 1,218 fish harvested during the 1986 ice fishery.

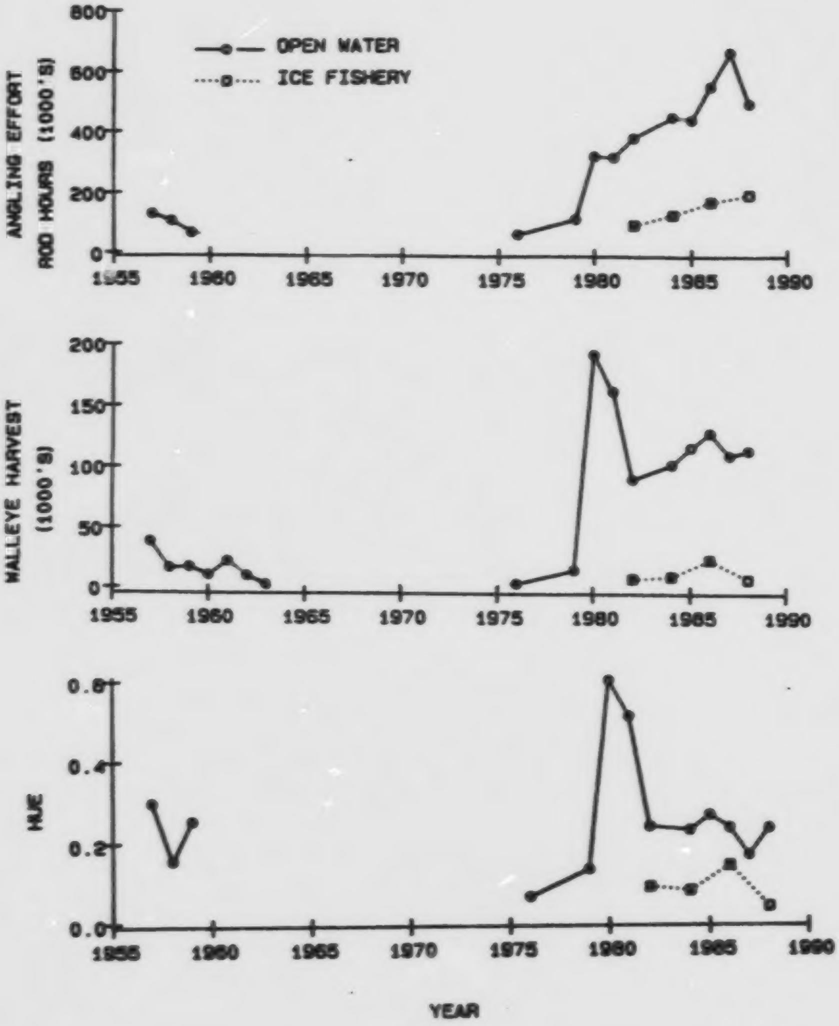

Figure 2. Trends in the Bay of Quinte sport fishery. Shown are estimates of angling effort, walleye harvest, and harvest per unit effort. The sources of the data were: Christie (1958), Watson (1964), Muldoon (1982) and Schaner (1986).

Table 2. Estimated walleye harvest (No. of fish) in the Bay of Quinte fishery, 1981 to 1988. Estimates are given for each angling season including the opening weekend (Opening) and the winter ice fishery (Jan. Feb.). No data available for 1983.

Angling Season	Year 1981	1982	1984	1985	1986	1987	1988
Jan. Feb.	-	8223	9869	-	23768	-	7416
Opening	-	-	5527	11009	8507	17240	11839
May[a]	56454	50232	55777[e]	65917	80962	75230	53079
June	38096	8289	-	3793	5877	6617	9438
July	40428	16308	24522[b]	27884[b]	15027	6332[d]	37215
Aug.	19091	11743	11035[b]	12548[b]	18659	14732[b]	9591
Sept.	2669	1381	1839[b]	2091[b]	2605[b]	2455[b]	
Oct.	3606	1059	2452[b]	2788[b]	3474[b]	3274[b]	5014[f]
Nov.	1796	1170[b]	1226[b]	1394[b]	1737[b]	1637[b]	
Dec.	0[c]	0[c]	0[c]	0[c]	0[c]	0[c]	0[c]
Open water Totals	162140	90182	102379	116415	128341	110277	114337
Annual Totals	-	98405	112248	-	152109	-	121753

[a] May data include the opening weekend data.

[b] Estimated based on current year's May and June total and the trend through season from 1981.

[c] Fishing effort in December remains unquantified but is considered negligible.

[d] The July 1987 estimate is extrapolated from data from July 1 to July 15, 1987.

[e] Separate May and June estimates for 1984 are not available.

[f] During 1988 September, October, and November were considered to be one season.

Dentry (1984) and Schaner (1986) observed that walleye CUE's for open ice anglers tend to be higher than for hut anglers. During the 1988 survey a significantly (X^2 = 17.332, p=0.0001) higher proportion of the 'on ice' anglers caught walleye (24.9% of those interviewed) than did hut anglers (10.4% of those interviewed) (Table 3).

Table 3. Catch per unit effort (CUE - # fish per angler hour) and harvest per unit effort (HUE) observed for the 1988 ice fishery on the Bay of Quinte.

Species	On Ice		Huts	
	CUE	HUE	CUE	HUE
Northern Pike	0.005	0.005	0.004	0.004
Yellow Perch	0.283	0.182	0.575	0.320
Walleye	0.110	0.076	0.023	0.020

Ice Fishery - Biological Characteristics of Harvest

The 1978 year-class (nine years old at their capture) were the most abundant fish in the harvest followed by the 1982, 1984, and the 1983 year-classes (Figure 3). The mean weight of the walleye sampled was calculated to be 2.198 kg (4.8 pounds).

Open Water Fishery - Angling Effort

We estimate the total angling effort at 497,078 (SE=16,147) rod hours (or 48,710 boat trips) for the whole open water fishery (Table 1). This estimate is slightly lower than 1987 and is similar to 1986, 1985, and 1984 (Figure 2). July showed an increase in angling effort relative to recent years, the opening weekend and June stayed stable, and May and August showed a decrease. The large angling effort observed in July was concentrated mostly in the Point Anne, Deseronto, and Long Reach areas (Table 4).

This was the first year since 1982 that angling effort has actually been measured during September, October, and November. The fall estimates of angling effort for 1984 to 1987 are extrapolations from the May and June data using the seasonal pattern from 1981 (Schaner 1986). During 1988, 1981 and 1982 the angling effort during the fall represented approximately 10% of the effort for the whole open water season.

Table 4. Distribution of angler effort (angler hours) by area during the 1988 open water fishery on the Bay of Quinte.

Area	Open	May	June	July	Aug.	Fall	Total
Trenton	16060	17322	11715	9547	5247	7894	67785
Maketewis Is.	455	1372	56	999	0	0	2882
Belleville	3361	6247	2780	5261	3129	4235	25013
Pt. Anne	5847	15150	5106	17213	10917	10763	64996
Trident Pt.	5952	13343	4979	8932	6024	7038	46268
Telegraph Nr.	6995	11297	3457	6165	1792	5403	35109
Deseronto	20435	36080	10319	18708	9624	5416	100582
Napanee R.	7125	5466	3684	991	1254	218	18738
Long Reach	17836	22229	6755	15847	14807	6614	84088
Hay Bay	5080	12756	5064	8657	4278	1449	37284
Baggot's Bay	1829	1290	309	2754	6422	1538	14142
Picton Bay	0	0	0	31	168	0	199
Total	90975	142552	54224	95105	63662	50568	497086

Open Water Fishery - Catch and Harvest

Twenty-three species of fish were captured during the 1988 open water fishery, and 156,120 fish from 14 of these species were harvested (Appendix 1). Walleye represented 73% of the harvest. Other important species in the harvest were yellow perch (19,875 fish harvested), white perch and/or white bass (6,075 fish), freshwater drum (3929 fish), smallmouth bass (2,909 fish), rock bass (2,757 fish), and northern pike (2,258 fish).

The 1988 estimate of walleye harvest (114,337, SE=7,499) suggests that the fishery has not changed dramatically relative to previous years (Figure 2 and Table 2). The harvest in June and July was higher than almost all other years surveyed, however, all other months showed below normal harvests. The 1988 catch of walleye (200,814 fish), on the other hand, was larger than for any previous survey in the Bay of Quinte. Forty-three percent of the fish which were caught were released. Anglers reported that the majority of the fish released weighed less than 0.5 lb. (0.23kg).

A large proportion (35%) of the walleye harvest during the month of July occurred at Deseronto (Table 5). This harvest and that observed during May at Deseronto were the largest harvests observed for any single area during the whole year. Together they represent 22% of the total annual harvest of walleye. Large numbers of the fish caught were released (14,658 fish or 53.2% of the catch) during the July fishery at Deseronto. Several angling parties reported releasing over 50 walleye in one trip.

Table 5. Distribution of walleye harvest by area during the 1988 open water fishery on the Bay of Quinte.

Area	Open	May	June	July	Aug.	Fall	Total
Trenton	2330	1396	2372	512	297	2155	9062
Maketewis Is.	41	0	0	0	0	0	41
Belleville	154	717	278	1130	145	1563	3987
Pt. Anne	504	3430	733	6581	2164	564	13976
Trident Pt.	451	3257	922	2490	1018	120	8258
Telegraph Nr.	1052	7964	798	1237	226	0	11277
Deseronto	3759	13310	1831	12887	2146	289	34222
Napanee R.	1015	2175	1187	198	15	0	4590
Long Reach	2276	5746	340	6531	1717	220	16830
Hay Bay	177	3078	977	4501	125	54	8912
Baggot's Bay	82	166	0	1148	1729	49	3174
Picton Bay	0	0	0	0	9	0	9
Total	11841	41239	9438	37215	9591	5014	114338

This was the first year since 1982 that walleye harvest has actually been measured during September, October, and November. The fall estimates of walleye harvest for 1984 to 1987 are extrapolations from the May and June data using the seasonal pattern from 1981 (Schaner, 1986). During 1988, 1981 and 1982 the angling effort during the fall represented approximately 4% of the harvest for the whole open water season.

Open Water Fishery - Biological Characteristics of Harvest

The 1985 year-class (3 years old when captured) were the most abundant fish in the harvest (Figure 3). The 1984 and 1986 year-classes (4 and 2 years old respectively) were moderately abundant. Only 6% of the harvested fish were two years old during May, however, this proportion jumped to 16% to 29% for the later seasons in the survey. The mean weight of the walleye sampled was calculated to be 0.788 kg (1.7 pounds).

The fish harvested by anglers during the ice water fishery were from a wide variety of age groups. The older age groups comprised a much larger proportion of the harvest than during the open water fishery which is dominated by the younger age groups (Figure 3). This was also found by Schaner (1986).

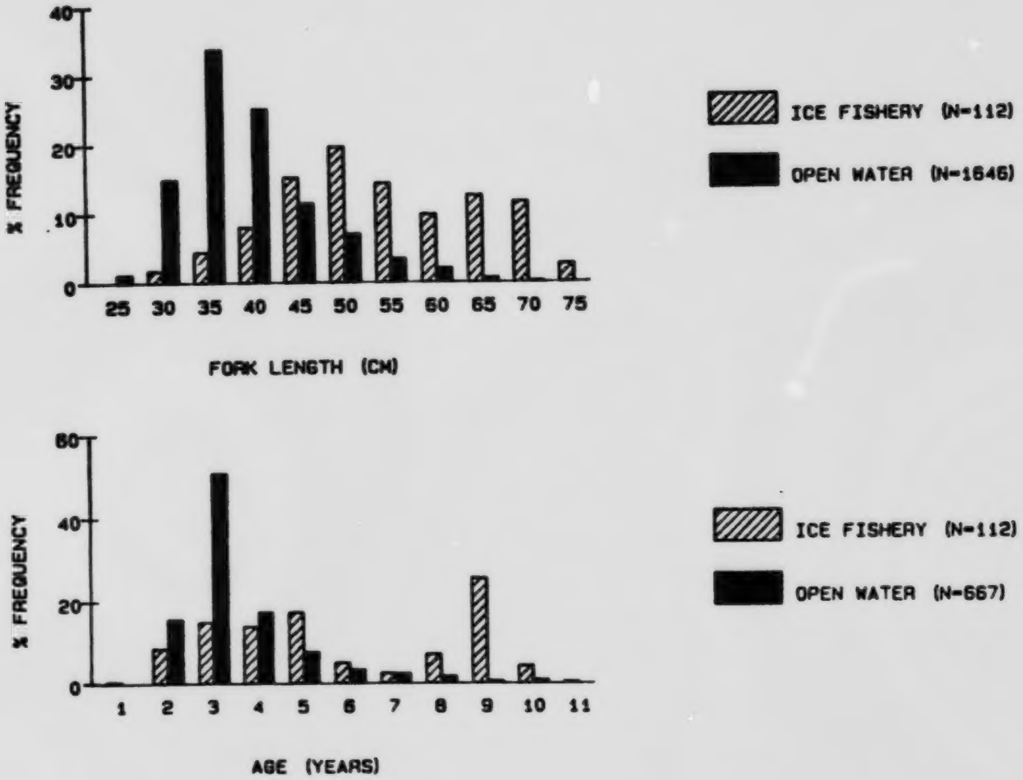

Figure 3. Fork length and age distributions of walleye harvested in the open water and ice fisheries.

DISCUSSION

Trends in Walleye Harvest

Changes in the walleye harvest rate (Figure 2) could be due to a variety of factors including: angler behavior, forage abundance, movement of walleye out of the Bay, walleye year-class strength or some combination of these and other factors. Walleye year-class strength is highly variable in the Bay of Quinte and the catch of young of the year walleye in the trawling program in the Bay can be used an indicator of the size of the year-class (Hurley, personal communication). In recent years angler selectivity has been highest on 3 and 4 year old walleye (Bowlby and Mathers 1989). The 1984 year-class (4 years old during the 1988 open water fishery) was not a strong year-class. The 1985 year-class (3 years old) is fairly strong and was the most abundant year-class in the harvest. The 1986 year-class (2 years old), which is a strong year-class, showed up in the 1988 open water fishery in large numbers. The 1986 year-class in combination with the 1985 year-class should provide a very good open water fishery next year. The 1987 year-class is also thought to be fairly strong and should provide good fishing in the future.

The walleye harvest and harvest per unit effort in the Bay of Quinte has remained relatively stable since 1982 (Figure 2). Although the harvest rates have declined from 1980 and 1981 those levels were probably abnormally high due to the rebound of the walleye population. Considering the strong year-classes entering the fishery, it is unlikely that walleye harvest levels will decline before 1991.

Catch and Release Fishing

Encouraging catch and release fishing is a management technique used in attempt to reduce harvest without reducing fishing opportunities. Minimum size limits and slot limits are examples of these regulations. Since the early 1980's an increasing proportion of the walleye caught by anglers in the open water fishery have been released (Figure 4). This has occurred even though no size limit regulations have been in place.

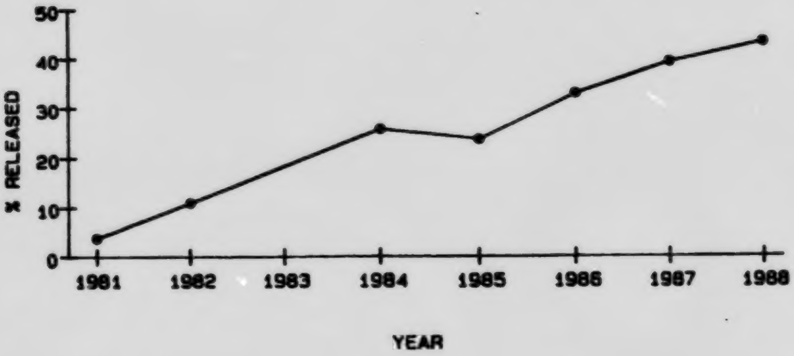

Figure 4. Proportion of walleye catch which is released by anglers in the Bay of Quinte open water sport fishery.

During the early 1980's the 1978 year-class dominated the angling fishery while in more recent years several year-classes have been present at once (Figure 3). The wider variety of sizes of fish present may explain the increase in the release of fish caught. Also, angling organizations have been encouraging anglers to release fish they have caught.

During the 1988 open water fishery 86,477 walleye were released by anglers. Anglers were asked to estimate the size of the the walleye they released. Information on 383 released fish were gathered - 65% were estimated to be less than 0.5 lb., 33% were 0.6 to 1 lb., 2% were greater than 1 lb. While it is difficult to be quantitative without actually examining these fish it is fair to say that the majority of these fish would have been in the two year old age group. If a 35 cm minimum size limit had been in place during 1988 the annual walleye harvest would be reduced by 29%. A 30 cm size limit would have reduced the harvest by 9%. The reduction in harvest would have its greatest effect on the open water fishery. There is very little effect on the ice fishery since few small fish are harvested (Figure 3).

We do not have quantitative estimates of the natural mortality (including hooking mortality) for two year old fish, however, it is thought to be approximately 20% (Bowlby and Mathers 1989). If this approximation is correct then encouraging live release of the small fish would increase the numbers of large fish available to anglers the following year.

Influence of Daily Harvest Restrictions

Changing the daily harvest limit is a management option often considered in attempt to reduce harvest. In attempt to quantify the effect of daily harvest restrictions the following model was constructed using data collected during interviews with anglers from 1981 to 1988:

1) the frequency distribution of harvest per unit effort follows a negative binomial distribution,

2) the distribution was multiplied by the length of the average angling day to predict the harvest distribution if no harvest limits were in place (Figure 5),

3) the effect of the daily harvest restrictions were quantified by comparing the predicted distribution to the distribution trimmed to match the harvest restriction.

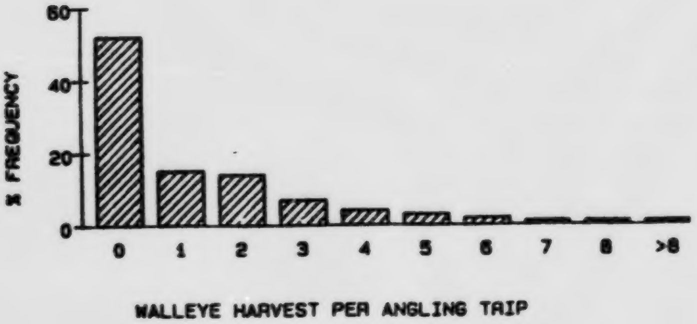

Figure 5. The frequency distribution of walleye harvest per angler trip assuming that there is no daily harvest limit. The data for this estimate are from Bay of Quinte open water fishery, May and June 1988.

Interview data from May (excluding the opening weekend) and June were used. Interviews with less than one rod hour of fishing were excluded. The length of the average angling day was calculated by doubling the mean length of time between the start of the angler's fishing trip and the interview time.

This model assumed that trip length and harvest rate would be unrelated for anglers if no daily harvest restrictions were in place. It was also assumed that the harvest rate after the interview will remain the same as before the interview. Anglers were assumed to make only one fishing trip per day.

The percentage reduction in walleye harvest were very similar for the different years analyzed. The only exception was 1981 (the year with the highest HUE) which seemed to have slightly larger percent reductions than the other years. When the data from 1981 to 1988 were averaged they predicted that if the daily bag limit was increased from its current level of 4 fish per day to 6 fish per day then the harvest would be increased by 9.9% (Figure 6). If the bag limit were reduced to 3 fish per day then 9.4% fewer fish would be harvested.

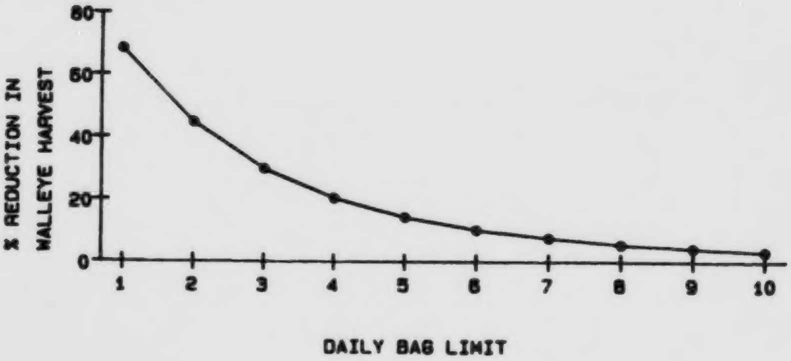

Figure 6. Reduction in walleye harvest (relative to no bag limit) which is estimated to occur if bag limits were imposed.

REFERENCES

BOWLBY, J. N. AND R. A. MATHERS. 1989. Walleye populations in eastern Lake Ontario and the Bay of Quinte, 1988. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 89.01.

CHRISTIE, W. J. 1958. The Bay of Quinte sport fishery survey - 1958 progress report. Glenora Fisheries Station, Ontario Ministry of Natural Resources, Internal Report GFS 1-58.

DENTRY, W. 1984. Sport fishing harvest from the upper Bay of Quinte, January to March, 1984. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 84-8.

LESTER, N. P. AND E. A. TRIPPEL. 1985. Fisheries information system, CREESYS manual. Ontario Ministry of Natural Resources.

MATHERS, R. A. 1988. Bay of Quinte creel survey, winter 1988. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 88-3.

MULDOON, J. A. 1982. Summer creels census in the Bay of Quinte, 1980-1981. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 81-4.

SCHANER, T. 1986. Bay of Quinte angling surveys, 1981-1986. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 86-14.

WATSON, N. H. F. 1964. Sport fishery survey. Glenora Fisheries Station, Ontario Ministry of Natural Resources, Internal Report GFS 2-64.

APPENDIX 1. Catch and harvest estimates for the fish species caught in the 1988 open water and ice fisheries. Standard errors of the estimates are given in brackets.

	Open Water Fishery		Ice Fishery	
Species	Catch (SE)	Harvest (SE)	Catch	Harvest
Bowfin	89 (45)	0 (0)	0	0
Alewife	106 (94)	0 (0)	0	0
Chinook Salmon	19 (16)	0 (0)	0	0
Rainbow Trout	16 (12)	0 (0)	0	0
Lake Herring	77 (69)	77 (69)	0	0
Northern Pike	8774 (915)	2258 (378)	760	760
Muskellunge	110 (67)	0 (0)	0	0
Mooneye	15 (13)	0 (0)	0	0
White Sucker	286 (126)	9 (8)	0	0
Common Carp	146 (0)	0 (0)	0	0
Brown Bullhead	9444 (1466)	1670 (340)	0	0
Channel Catfish	5844 (871)	1219 (251)	0	0
American Eel	105 (50)	0 (0)	0	0
Morone species	52941 (6347)	6075 (879)	0	0
Rock Bass	18506 (1808)	2757 (602)	0	0
Pumpkinseed	4624 (878)	937 (348)	0	0
Bluegill	166 (84)	23 (20)	0	0
Smallmouth Bass	15848 (1550)	2909 (559)	0	0
Largemouth Bass	548 (153)	45 (34)	0	0
Black Crappie	23 (21)	0 (0)	0	0
Yellow Perch	130015 (11627)	19875 (3078)	73534	39915
Walleye	200814 (17893)	114337 (7499)	12987	7416
Freshwater Drum	33472 (3764)	3929 (715)	0	0

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AN EVALUATION OF THE 1988 YELLOW PERCH GILLNET FISHERY IN EASTERN LAKE ONTARIO BASED ON 'ON-BOARD SAMPLES'

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ABSTRACT

The eastern Lake Ontario small mesh fishery for yellow perch was monitored through an on-board sampling project from April through December of 1988. Sampling relied on cooperation from the commercial fishermen, and all fishermen except those from the Brighton area chose to participate in the project. During this time, the fishermen reported that they set 1,511,672 meters of small mesh gill net and captured 71,725 kg of yellow perch. We sampled 109,062 meters or 7.2% of the net fished, and examined 5,691 kg of fish. The most heavily fished and sampled area was south of Amherst Island, with the greatest effort expended during July. The target species, yellow perch, made up 78% of the total weight of fish caught during on-board sampling. Sport fish made up 6.8% of the total. Compared to 1987, a remarkable increase in the number of large yellow perch caught was seen. The time and area specific closures appear to have been effective in reducing incidental catches of sport fish species. We estimate that at least 6,829 kg of sport fish were caught by the commercial fishermen, about 30% of which would have been released alive and expected to survive. Walleye and smallmouth bass predominated in the incidental catches. Recommendations are made to further reduce mortalities of incidentally caught sport fish and improve the status of perch stocks in the area.

RECOMMENDATIONS

1. During the summer months and when weather permits, commercial fishermen should check their nets daily. This would increase the number of sport fish which could be released alive.

2. The self policing program should be continued. Fishermen should seriously consider increasing both the mesh size of nets used and the minimum size of the perch retained for sale.

3. Data should be collected from the Brighton area in order to quantify estimates of incidental catch for quota zone 1.

4. Where we have months or areas with only a few samples and a large incidental catch of sport fish, additional sampling should be conducted and commercial fishing practices may have to be altered. This would include Adolphus Reach during April and December and the area around the False Duck and Timber Islands during the summer.

1. Background

The incidental catch of sport fish in the commercial gillnets in eastern Lake Ontario has become a major issue in recent years. Those species for which the commercial gillnet fishery has a zero quota such as walleye and lake trout are considered for the purposes of this study to be sport fish. The yellow perch fishery typically uses gillnets measuring between 2 1/4" and 2 5/8" stretched mesh. A study conducted during May and June of 1987 found that these gill nets also captured substantial amounts of walleye, lake trout and other sport fish species (Dentry 1988), and that many of the yellow perch caught were too small to be marketable. In March of 1988, the Minister of Natural Resources announced that gill nets would be prohibited in:

Quota Zone 1 ... during the months of May through July
Quota Zone 2 ... during the months of May and June
Quota Zone 4 ... during the months of May through August

These restrictions were intended to reduce the incidental catch of sport fish and to aid in fisheries rehabilitation activities for lake trout.

To protect perch stocks and produce a more marketable product, the commercial fishermen agreed to continue a self policing program aimed at restricting harvested yellow perch to fish over 7 1/2" in total length.

This study was designed to evaluate the attributes of the catches of both the target species, yellow perch, and any sport fish species which might be caught incidentally by the eastern Lake Ontario small mesh gillnet fishery. Where possible, data were collected directly from the commercial fishermen as the nets were being lifted, a process referred to as 'On-Board Sampling' or OBS.

In the past it has not always been possible to collect data directly from the commercial fishermen. To ensure that the study objectives would still be met in the event that too few on-board samples were collected, a companion project was conducted concurrently with this study. In the companion project, a small team of technicians from the Lake Ontario Fisheries Unit (LOFU) set up and ran a small mesh gill net fishery designed to simulate as closely as possible commercial fish operations in the immediate area. This project is described in Dentry (1989).

2. Time and Area Stratification

This study began in April and ended in December of 1988. For reporting purposes, data were grouped by month according to the date on which the nets were lifted.

The locations of each net sampled and of any nearby nets which were not sampled were drawn onto a 1:61,243 scale map which was partitioned into 5 minute grids. The study included three quota zones (QZ) over a one hundred kilometer range from Brighton in the west to Kingston in the east. A wide range of habitats were encompassed from shallow, weedy areas to sand flats or immense, bare plates of submerged limestone hundreds of meters wide. The lower Bay of Quinte consisting of Adolphus Reach and the North Channel, is separated from the Kingston basin by sills at the upper and lower gaps (Sly

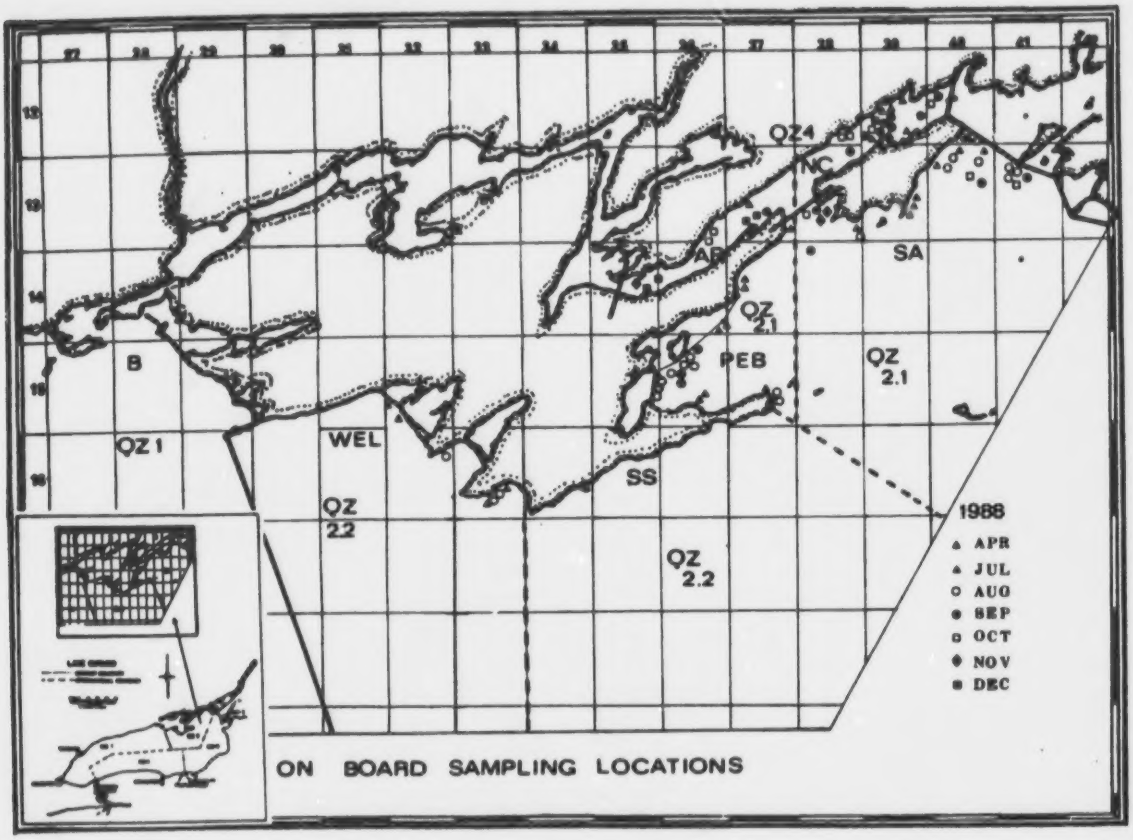
QZ4
NC
AR
SA
QZ 2.1
PEB
QZ 2.1
B
QZ1
WEL
SS
QZ 2.2
QZ 2.2
1988
▲ APR
▲ JUL
○ AUG
● SEP
□ OCT
◆ NOV
■ DEC
ON BOARD SAMPLING LOCATIONS

Figure 1. Locations where on-board samples were collected. The grid numbers are numbered by the five minute system.

1986). The area is also biologically heterogeneous, as is evidenced by the very different fish assemblages found in index fishing stations throughout the area (Hurley 1986; Mathers and Bowlby 1988). At least three different yellow perch stocks appear to exist (Schaner and Dentry 1984). Because of these differences, the data have been grouped for analysis into seven areas. Their abbreviations and the quota zones that they are in are as follows:

1. Adolphus Reach (AR; QZ 4)
2. North Channel (NC; QZ 4)
3. Area south of Amherst Island (SA; QZ 2.1)
4. Prince Edward Bay (PEB; QZ 2.1)
5. South shore of Prince Edward County from Point Traverse to Point Petre (SS; QZ 2.2)
6. Wellington, the south west shore of Prince Edward County from Point Petre to Nicholson Point (WEL; QZ 2.2)
7. Brighton (B; QZ 1).

A total of 85 samples were collected during the study (Table 1). The majority of the samples collected were obtained from the North Channel, the area south of Amherst Island and Prince Edward Bay (Fig. 1). No samples were collected during May or June as all areas were closed to all netting during this time. Most of the samples were obtained during July through September, and quota zone 2.1 and the North Channel area of quota zone 4 were the most heavily fished. Only one sample was obtained in quota zone 1 as Brighton area fishermen chose not to cooperate in the on-board sampling program.

Table 1. A summary of the number of on-board samples collected in 1988. The 'x' indicates that quota zone 4 was also closed to gillnetting during July and August, while the dot "." indicates that no samples were collected, even though the season was open.

Quota Zone	Area	Apr	Jul	Aug	Sep	Oct	Nov	Dec	Total
4	Adolphus Reach	1	x	x	1	2	.	1	5
4	North Channel	5	x	x	8	4	2	4	23
2.1	South of Amherst	.	8	11	4	3	2	.	28
2.1	Prince Edward Bay	.	10	9	3	.	.	.	22
2.2	South Shore	.	.	.	.	.	.	.	0
2.2	Wellington	.	3	3	.	.	.	.	6
1	Brighton	.	1	.	.	.	.	.	1
	Total	6	22	23	16	9	4	5	85

3. Setting and Site Descriptions

Minimum and maximum depths straddled by the net were recorded for each set.

Two common setting techniques were employed, "picket fencing", an arrangement of short straps of net set adjacent to each other and perpendicular to the shoreline, and "railing", a wavey set pattern designed to cover a wide range of bottom contours. In both techniques a wide range of depths were often covered by any single net. Most fishermen concentrated their nets in the shallower, nearshore waters of their license area. Nets were generally set in deeper waters during the summer when surface water temperatures were higher (Table 2).

Table 2. Set depths in meters.

Area or Month	N	Av Min	Av Max	Av Diff
Adolphus Reach	3	7	19	12
North Channel	27	10	21	11
South of Amherst	26	14	21	7
Prince Edward Bay	22	11	16	5
Wellington	6	2	5	3
Brighton	1	1	4	3
April	6	5	13	8
July	22	6	13	7
August	23	12	16	4
September	16	19	25	6
October	9	13	22	9
November	4	3	19	16
December	5	5	26	21

4. Effort Statistics

A total of 109,062 meters of net were sampled. Most (71.3%) was estimated to be 57 mm or 2 1/4" stretched mesh and had been set in quota zones 2.1 and 4 (Table 2). Less than 10% of the mesh seen was estimated to be 2 5/8" stretched mesh (Table 3). A month by month breakdown for each mesh size is provided in Appendix 1.

Effort data were collected separately for each piece of monofilament and multifilament gill net which had been set. These data included the length of the net in meters, mesh size in millimeters, the number of meshes in the panel depth, and the number of hours that the gear had been in the water.

Table 3. Meters of net sampled by LOFU during 1988.

Quota Zone	Area	Stretched Mesh Measure (mm) 57	59	60	62-64	67	Total Meters Sampled
4	Adolphus Reach	732	732	585	0	0	2049
4	North Channel	15833	1828	6401	2414	0	26476
2.1	Prince Edward Bay	22221	4718	1536	640	5651	31766
2.1	South of Amherst	32402	4207	1097	0	2286	39992
2.2	Wellington	5560	0	0	0	2195	7755
1	Brighton	1024	0	0	0	0	1024
Total	All Areas	77772	11485	9619	3054	10132	109062
%		71.3	10.5	8.8	2.8	9.3	

Much of the time the mesh size data were supplied verbally by the commercial fishermen, otherwise, these data were estimated by eye, by the samplers. Measuring gauges were not used to reduce confrontation between the fishermen and the sampling technicians. Fishermen left their nets in the water for periods of time ranging from a few hours up to six days. The longest set times were in the spring and fall when cool water temperatures helped to preserve captured fish (Table 4); these were also the times when adverse weather conditions prevented fishermen from lifting their nets daily.

Table 4. Set durations in hours.

Area or Month	N	Min	Max	Average
Adolphus Reach	3	18	72	38
North Channel	27	20	144	54
South of Amherst	26	12	120	30
Prince Edward Bay	22	18	48	26
Wellington	6	12	20	14
Brighton	1	2	2	2
April	6	18	144	99
July	22	2	48	25
August	23	12	24	22
September	16	14	44	25
October	9	21	44	35
November	4	48	120	78
December	5	24	96	67

Table 5. Total observed catch weights by species for all areas and months combined in the 85 samples collected.

Species	Total kg	%	#
Commercial Species			
Rainbow Smelt	2.0	<.1	*
White Perch	150.8	2.7	
Yellow Perch	4437.0	78.0	
Common White Sucker	171.6	3.0	
Brown Bullhead	22.8	0.4	
Rock Bass	258.9	4.6	
Lake Herring	18.8	0.3	
Lake Whitefish	43.5	0.8	
American Eel	1.8	<.1	
White Bass	7.8	0.1	
Burbot	2.3	<.1	
Channel Catfish	35.0	0.6	
Pumpkinseed Sunfish	3.7	0.1	
Crappie	0.3	<.1	
Long Nose Sucker	1.8	<.1	
Commercial subtotal	5158.1	90.7	
Sport Fish Species			
Brown Trout	14.1	0.2	32
Northern Pike	53.6	0.9	102
Walleye	160.0	2.8	1285
Rainbow Trout	1.0	<.1	6
Lake Trout	62.2	1.1	119
Smallmouth Bass	93.7	1.6	803
Chinook Salmon	2.0	<.1	9
Sport subtotal	386.7	6.8	2356
Other Species Caught			
Long Nose Gar	8.2	0.1	
Gizzard Shad	14.3	0.3	
Trout-Perch	0.5	<.1	
Sea Lamprey	0.9	<.1	
Alewife	103.1	1.8	
Freshwater Drum	18.1	0.3	
Stonecat	0.2	<.1	
Fallfish	0.5	<.1	
Other subtotal	145.8	2.5	
Grand total	5690.6	100.0	

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*The number of commercial fish sampled has not been included since they were not all counted.

5. Catch Sampling

The catch was usually sampled as it was brought on-board the vessel. The commercial nets typically used in this fishery are made up by tying together an array of monofilament and multifilament nets, each of which may consist of one or more mesh sizes in a variety of depths. Varying degrees of picking occurred as the nets were hauled. All of this made it difficult to record catch statistics on an individual panel basis, so while net attributes (mesh size etc.) were recorded for each panel, catch statistics are for the entire array of nets fished.

A total of 5,691 kg of fish were sampled during the study, 78% of which were yellow perch, 12.7% were other commercial fish species, 6.8% were sport fish, and 2.5% were 'other' species (Table 5). Appendix 2 presents a more detailed month/area breakdown for each species. These results are a sharp contrast to those seen in May and June of 1987, when sport fish made up 30% of the catch and yellow perch made up only 39% of the catch (Dentry 1988). Because of the season restrictions during 1988 it was not possible to make direct time area comparisons between 1987 and 1988. However, these results suggest that the closure has been effective in reducing the incidental catch of sport fish. Also, the generally later season allows the fish to grow larger before being subject to commercial gillnet fishing, as will be discussed further in section 9.

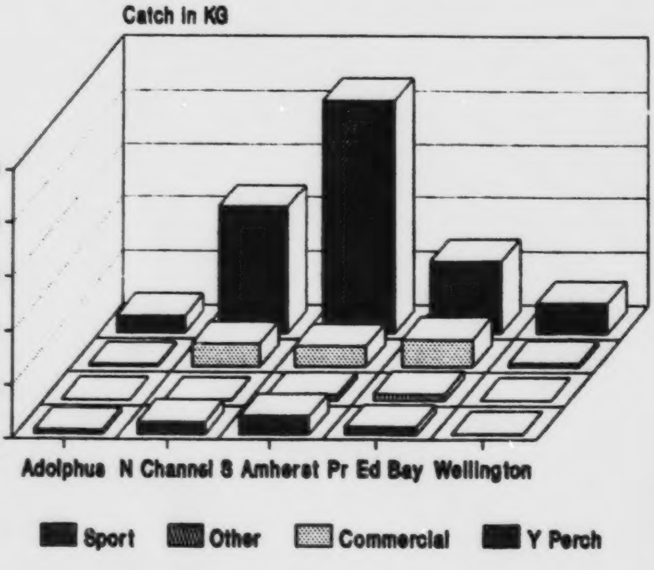

Figure 2. Catches sampled by species group in each area.

Both the LOFU sampling and the commercial fishermen's harvest were primarily from the area south of Amherst Island, the North Channel and Prince Edward Bay

(Fig. 2). Effort dropped markedly in November when the fishermen concentrated their efforts on fishing for Lake Whitefish with large mesh gillnets south of Prince Edward County (Fig. 3).

More than 80% of all fish caught were sold as food and 12.2% were discarded. The aggregate weight of the catch of all species other than commercially salable and sport fish species was recorded according to whether they were kept or discarded. Discarded fish included undersized commercial species and species such as lamprey.

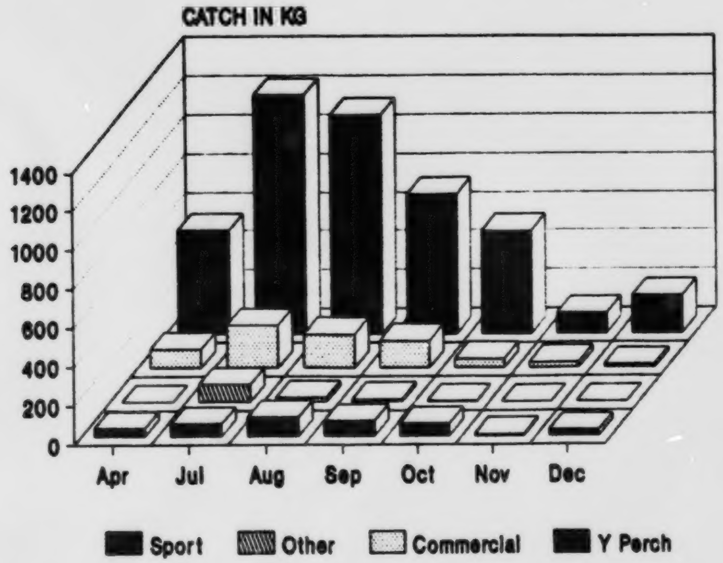

Figure 3. Catches sampled by species group during each month.

6. Sport Fish Catches

Commercial fishermen removed sport fish from nets and returned them immediately to the lake, as is directed by MNR. This further restricted the data which could be collected. Sport fish were visually enumerated by species into one of four different weight classes: < 1 lb, 1-3 lb, 3-5 lb or over 5 lb and classified according to whether or not they were likely to live after being released.

Incidentally caught sport fish made up 6.8% of the total catch (Table 5). The most frequently caught sport fish was walleye (Fig. 4).

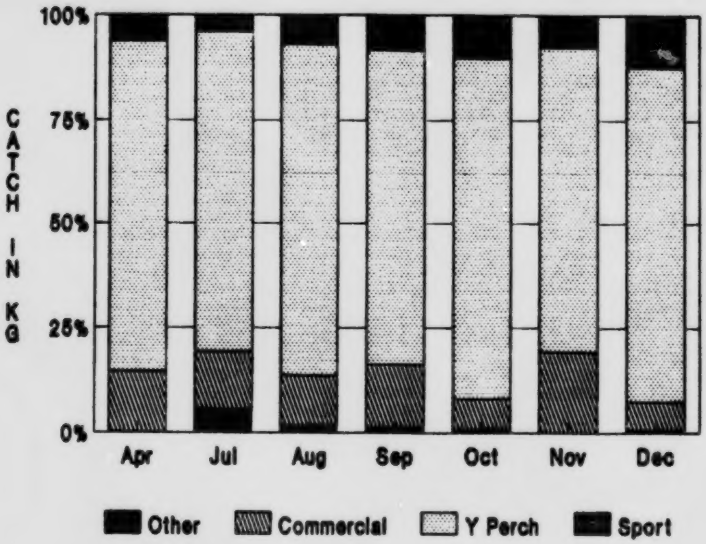

Figure 4. Percentages of each species of sport fish in the sampled catch. Data are for all areas and months combined.

About 30% of these were released alive and expected to live, although this varied considerably by species (Table 6). These results are similar to what was seen during May and June of 1987. The proportion of fish which can be returned alive to the water is dependent on how fish are handled, the water temperature, and on how long the gear is left in the water.

Fewer mortalities were seen in nets which were fished for 24 hours or less, and in nets set during the spring and fall when water temperatures were lower. During May and June of 1987, lake trout made up 45% of the incidental catch of sport fish, walleye 32% and smallmouth bass and northern pike about 10% each (Dentry 1988). This year, lake trout constituted 16% and walleye 41% of the weight of the sport fish catch, and smallmouth bass and northern pike catches were also considerably greater this year than last. The reduction in lake trout seen this year reflects the fact that these fish move to colder, deeper habitats as summer progresses and nearshore habitats become warmer. Walleye on the other hand tend to move out of the Bay of Quinte during the early summer and to return in the fall (Payne 1963). Since most of our samples were collected during the summer when water temperatures are highest, these results are as expected. Walleye however appear to be more than three times as likely to die as are smallmouth bass, and we suspect that this may be due to their shape. These one and two year old walleye are very streamlined and torpedo-shaped, and probably swim further into the mesh than do the deeper-bodied smallmouth bass. This would restrict their ability to operate their operculae, and more of them would suffocate.

Table 6. Catches and disposition of sport fish species. "A" indicates that the fish were released alive, "D" that they were returned to the water dead. Data are for all months and areas combined.

Species		Weight kg	Weight %	Catch #	Catch %
Brown Trout	A	6.3	1.6	14	0.6
	D	7.8	2.0	18	0.8
Northern Pike	A	18.9	4.9	37	1.6
	D	34.7	9.0	65	2.8
Walleye	A	38.4	9.9	278	11.8
	D	121.6	31.4	1007	42.7
Rainbow Trout	A	<.1	<.1	0	<.1
	D	1.0	0.3	6	0.3
Lake Trout	A	26.3	6.8	36	1.5
	D	35.9	9.3	83	3.5
Smallmouth Bass	A	37.1	9.6	313	13.3
	D	56.6	14.6	490	20.8
Chinook Salmon	D	2.0	0.5	9	0.4
Total		386.7	100.0	2356	100.0

Accordingly, we recommend that during the summer months and when weather permits, commercial fishermen should check their nets daily. This would increase the number of sport fish which could be released alive.

Figure 5 shows the data from Fig. 2 expressed as a percentage of the sampled catch seen in each area. Sport fish made up a low of 2.0% of the sampled catch in Wellington to a high of 15.8% of the sampled catch in Adolphus Reach. However, it should be noted that during July and August, all our data are from quota zone 2, and that this distorts somewhat the proportions of each species group in each area shown in Fig. 5. Similarly, Fig. 6 shows the data from Fig. 3 expressed as a percentage of the monthly catch. Viewed this way, sport fish comprised a low of 4.0% of the sampled catch during July up to a high of 12.7% of the catch sampled during December. Again, a caution is in order. The relatively high proportion of sport fish in April and December is strongly influenced by the large catches of northern pike in Adolphus Reach in the five samples collected from this area (see for example Appendix 2a-e). The data used to prepare these figures are presented in Appendix 3. These observations lead us to recommend that where we have months or areas with only a few samples and a very large incidental catch of sport fish, additional sampling should be conducted. In addition, commercial fishing practices may have to be altered. For example, our data suggest that incidental catches may be reduced by not setting in the Adolphus Reach during April and December or around the False Ducks during the summer. Appendix 4 provides some of the data needed to make these decisions.

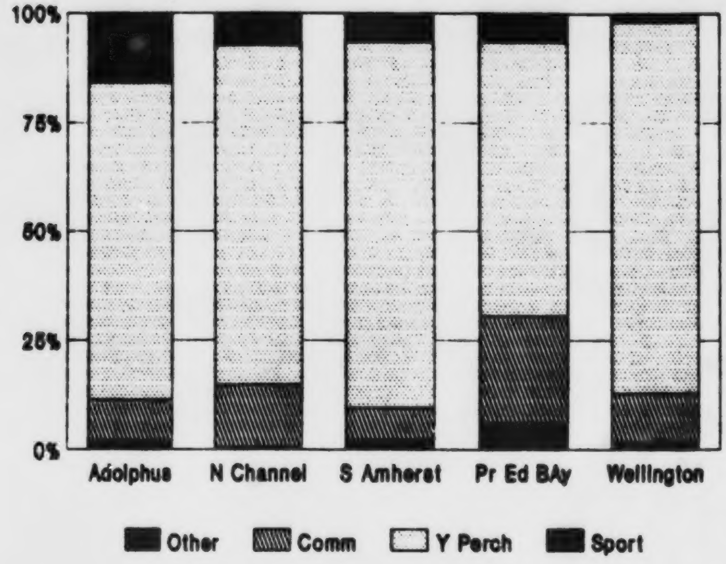

Figure 5. Proportions of species groups by area - all months combined.

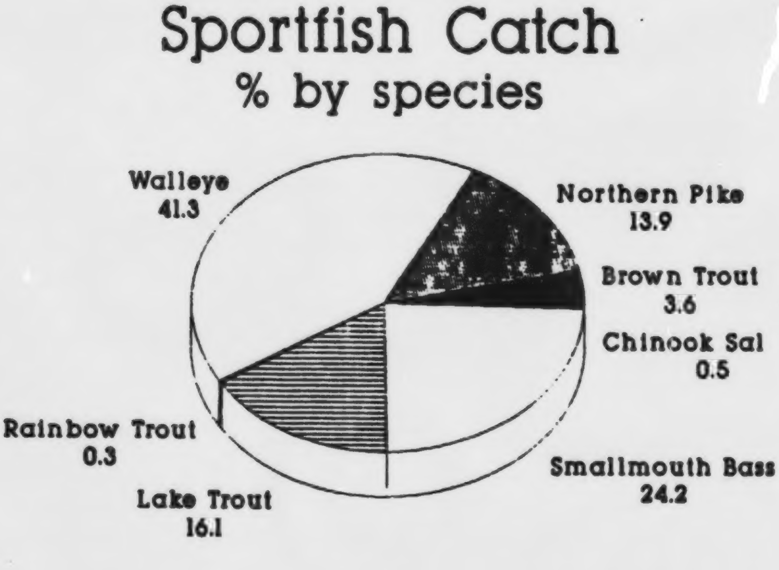

Figure 6. Proportions of species groups by month - all areas combined.

7. Reported Landings

The reported number of commercial lifts, meters of net set and lifted, and catches of yellow perch are shown in Tables 7, 8, and 9 respectively. The data in Table 8 do not necessarily represent a single nights fishing, and have not been standardized in any way. These data were obtained directly from the commercial fishermen's monthly (CF1) reports.

Table 7. The number of commercial lifts for yellow perch.

Area	Apr	Jul	Aug	Sep	Oct	Nov	Dec	Total
Adolphus Reach	16	.	.	1	26	8	3	54
North Channel	103	.	.	62	53	26	30	274
South of Amherst	15	88	94	63	49	6	1	316
Prince Edward Bay	.	63	91	49	15	3	2	223
Wellington	.	37	35	12	.	.	.	84
Brighton	.	1	111	29	.	.	.	141
Total	134	189	331	216	143	43	36	1092

Table 8. Meters of commercial net set for yellow perch.

Area	Apr	Jul	Aug	Sep	Oct	Nov	Dec	Total
Adolphus Reach	21854	.	.	1372	99487	14630	6401	143744
North Channel	51238	.	.	105796	71927	35817	25128	289906
South of Amherst	8348	154625	138513	57699	62252	12308	732	434477
Prince Edward Bay	.	95280	114803	59345	24140	5944	1920	301432
Wellington	.	40636	55687	24414	.	.	.	120737
Brighton	.	457	181600	39319	.	.	.	221376
Total	81440	290998	490603	287945	257806	68699	34181	1511672

Table 9. Weight (kg) of commercially caught yellow perch.

Area	Apr	Jul	Aug	Sep
Adolphus Reach	1318	.	.	16
North Channel	6508	.	.	5313
Prince Edward Bay	.	3637	2734	1515
South of Amherst	2468	7748	5838	3783
Wellington	.	4104	2143	892
Brighton	.	0	4211	1044
Total	10294	15489	14926	12563

Area	Oct	Nov	Dec	Total
Adolphus Reach	1341	653	229	3557
North Channel	3580	1157	1420	17978
Prince Edward Bay	309	165	50	8410
South of Amherst	7725	1808	16	29386
Wellington	.	.	.	7139
Brighton	.	.	.	5255
Total	12955	3783	1715	71725

8. Estimating Incidental Catches

If the amount of sampling conducted was sufficient to provide an adequate representation of the commercial fishing which actually occurred, then the sample data can be combined with the reported landings to estimate the weight of incidentally harvested fish in 1988. A bias could be introduced into the estimation if the samples collected came from lifts which contained fewer incidentally caught sport fish. All sampling depended on the cooperation of the commercial fishermen. With the exception of Brighton, the technicians doing the sampling felt that the level of cooperation was excellent, and that they saw a representative selection of the nets being fished.

They were not able to sample any of the 140 lifts in the Brighton area. Anecdotal evidence from conservation officers who checked Brighton area nets in the water suggests that we probably were not invited to sample these nets due to the relatively high proportions of sport fish species being caught. We recommend that data be collected from this area before estimates of incidental catch be quantified for quota zone 1.

In Table 10, the spatial and temporal sampling distribution is compared to the actual fishing which was reported. The 'CF' column contains the percent of the total number of CF lifts (example 54/1092*100 = 5% etc.) while the LOFU the total number of CF lifts (example 54/1092*100 = 5% etc.) while the LOFU column contains the percent of LOFU's total number of on-board samples. The effort calculations are also made using their respective totals. The CF data are from Tables 7 and 8, while the LOFU data are from Table 1 and Appendix 1. All times and areas except for Brighton appear to have been reasonably representatively sampled. The relatively poorer agreement in the comparisons of meters columns may reflect the fact that it is not readily possible to standardize the CF effort to a single nights fishing.

Table 10. Comparing sampling and reported effort.

	% of Lifts		% of meters	
Area or Month	CF	LOFU	CF	LOFU
Adolphus Reach	5	6	9	2
North Channel	25	27	19	24
South of Amherst	29	33	29	29
Prince Edward Bay	20	26	20	37
Wellington	8	7	8	7
Brighton	13	1	15	0
April	13	7	5	5
July	17	26	19	32
August	30	27	32	31
September	20	19	19	16
October	13	11	17	8
November	4	5	5	3
December	3	6	2	5

Incidental catches of sport fish species were then estimated by prorating the relative weight proportions sampled by the reported catch weights of yellow perch. This was done separately for each area and month except Brighton which was not adequately sampled. The relative percentages by weight of each species of sport fish and yellow perch were taken from Appendix 2a-e, and yellow perch landings were taken from Table 9. The following example uses data from Adolphus Reach during April of 1988 to illustrate the calculation used to estimate the weight of the incidental catch of brown trout: 0.04 (the % brown trout in the sample) * 292 (the kg of yellow perch reported as landed) / 0.67 (the % of yellow perch in the sample) = 17.4 kg (the estimated incidental catch of brown trout). Because no sampling was done in the area south of Amherst Island during April, in Wellington in September and in Prince Edward Bay during October, it has not been possible to estimate incidental catches of sport fish species for these areas and times. Consequently, the summaries presented in Table 11 represent an underestimate. The results of the detailed calculations are presented in Appendix 5a-e.

Table 11. A partial summary of incidental catches (kg) of sport fish (kg) during April to December of 1988. Species are brown trout (BT), northern pike (NP), walleye (WA), rainbow trout (RT), lake trout (LT), smallmouth bass (SMB) and chinook salmon (CS).

	BT	NP	WA	RT	LT	SMB	CS	Total
Adolphus Reach	116	535	214	0	51	0	0	914
North Channel	171	420	1182	2	774	143	1	2693
Prince Edward Bay	24	166	428	10	148	111	22	909
South of Amherst	22	4	1114	0	244	788	1	2173
Wellington	29	0	75	0	29	5	0	138
April	121	592	133	2	149	0	0	997
July	26	92	184	0	117	280	0	699
August	39	64	332	10	97	365	19	926
September	20	27	726	.	235	216	5	1229
October	127	172	1279	.	564	186	0	2328
November	0	35	254	.	30	0	0	319
December	29	143	105	.	54	0	0	331
Totals	362	1125	3013	12	1246	1047	24	6827

9. Yellow Perch Sizes

A random subsample of up to 100 yellow perch taken from each catch were weighed, and fork lengths were measured to the nearest centimeter. Size distributions of sampled yellow perch total lengths are presented in Table 12.

Table 12. The size distribution of the 7,657 yellow perch measured during the study. Fork lengths (FL) are in mm. TL indicates total lengths.

Group	Small		Medium		Large		Jumbo	
FL Range	155-174		175-184		185-194		195-285	
FL Classes	160-170		180		190		200-280	
TL inches	6.4-7.3		7.3-7.7		7.7-8.1		8.1-11.9	
	#	%	#	%	#	%	#	%
Adolphus Reach	16	3	88	18	149	30	246	49
North Channel	70	3	369	18	639	31	983	48
South of Amherst	64	2	312	11	783	28	1666	59
Prince Edward Bay	63	3	354	20	674	37	716	40
Wellington	10	2	81	18	162	35	209	45
Brighton	.	.	.	.	2	67	1	33

Table 12 (Concluded)

Group	Small		Medium		Large		Jumbo	
FL Range	155-174		175-184		185-194		195-285	
FL Classes	160-170		180		190		200-280	
TL inches	6.4-7.3		7.3-7.7		7.7-8.1		8.1-11.9	
	#	%	#	%	#	%	#	%
April	36	6	84	14	180	30	299	50
July	50	3	314	17	664	35	861	46
August	63	3	278	14	602	31	1002	52
September	32	2	272	18	512	33	717	47
October	25	3	150	20	207	28	356	48
November	6	1	14	3	79	17	353	78
December	11	2	92	18	165	33	233	47
ALL	223	3	1204	16	2409	31	3821	50

Size distributions were generally similar in all areas although the area south of Amherst Island had the largest percentage of jumbo size perch (59%; Fig. 7). The slightly greater proportion of small yellow perch caught in April is as expected since summer growth has not yet occurred. The predominance of jumbos during November is quite remarkable (Fig. 8), although only four lifts were sampled during that month. Dentry (1988) reported that 52% of all yellow perch seen during May and June of 1987 were marketable. The 1988 data show an astonishing increase (Fig. 9).

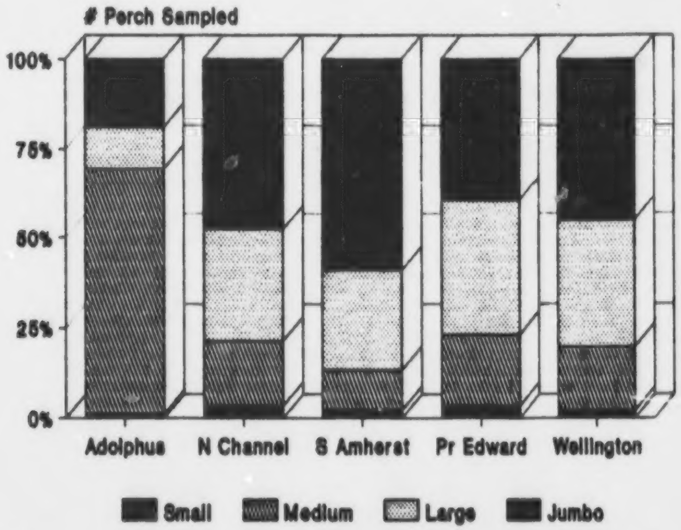

Figure 7. The size distributions of yellow perch sampled in each area.

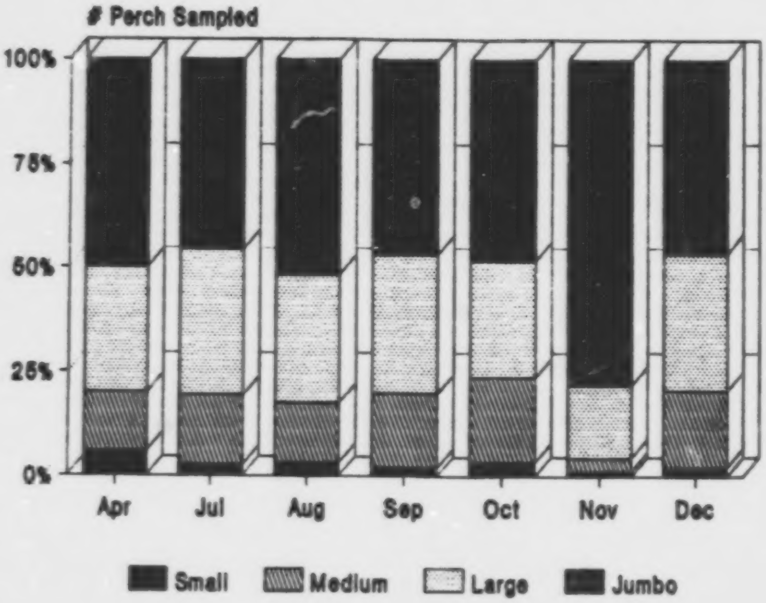

Figure 8. The size distributions of yellow perch sampled in each month.

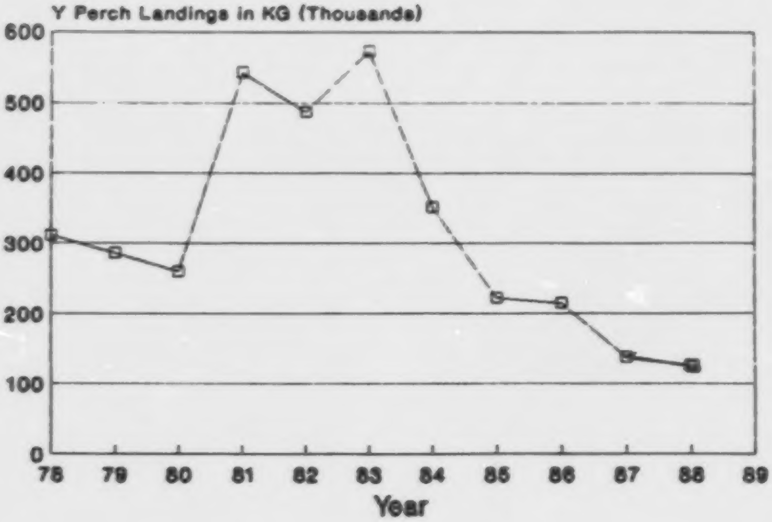

Figure 9. Reported landings of yellow perch.

Overall, it is estimated that over 90% of all yellow perch caught during this study were marketable fish, exceeding about 7.5 inches in total length. This improvement in size is at least partly due to the self policing exercised by the commercial fishermen since 1987.

Reported landings have been declining steadily since 1983 (Fig. 9). This may be the combined result of market forces, a reduction in effort brought about by the reduced number of fishermen in the fishery after the recent government sponsored buy out program, and/or changes in the stocks of fish available to the fishery. Recently prepared indices of exploitation suggest that stocks in quota zones 2 and 4 are returning to normal. This suggests that perch are highly resilient and able to recover rapidly from over-fishing. There has been considerable discussion about raising the minimum size to 7 3/4" from its current value of 7 1/2". If this had been done for 1988, about 20% of the perch caught would have been undersized. If perch stocks are to recover, a greater number of these fish should be allowed to reach a larger size and have more opportunities to reproduce. The use of larger mesh gill nets would reduce the number of small fish caught. An increase in the minimum size for yellow perch through a change to the self-policing program would assist in achieving this.

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REFERENCES

DENTRY, WILLIAM. 1988. Catches in small mesh gill nets during May and June 1987 in eastern Lake Ontario. *In* Lake Ontario fisheries Unit 1987 Annual Report. OMNR unpublished report.

DENTRY, WILLIAM. 1989. A simulated commercial fishery for yellow perch in eastern Lake Ontario. *In* the Lake Ontario fisheries Unit 1988 Annual Report. OMNR unpublished report.

MATHERS, A., AND J. N. BOWLBY. 1988. Index gillnetting project. *In* Lake Ontario fisheries Unit 1987 Annual Report. OMNR unpublished report.

HURLEY, D. A. 1986. Fish populations of the Bay of Quinte, Lake Ontario, before and after phosphorus control, p. 201-214. *In* C. K. Minns, D. A. Hurley, and K. H. Nicholls (ed.) Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

PAYNE, N. R. 1963. The life history of the yellow walleye *Steizostedion vitreum vitreum*, (Mitchell) in the Bay of Quinte. Thesis. MSc., Univ. of Toronto.

SCHANER, T., AND W. DENTRY. 1989. Commercial fish harvest assessment program. *In* the Lake Ontario fisheries Unit 1984 Annual Report. OMNR unpublished report.

SLY, P. G. 1986. Review of postglacial environmental changes and cultural impacts in the Bay of Quinte, p. 7-26. *In* C. K. Minns, D. A. Hurley and K. H. Nicholls (ed.) Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

APPENDIX 1. Meters of net sampled by month and area.

Area	Mesh size (mm)	Apr	Jul	Aug	Sep	Oct	Nov	Dec
Adolphus Reach	57	.	.	.	.	.	.	732
	59	.	.	.	732	.	.	.
	60	585	.	.	.	.	.	.
North Channel	57	732	1646	1897	4572	3639	732	2615
	59	1828	.	.	.	.	.	.
	60	.	.	.	3750	457	274	1920
	63	1170	.	.	.	.	.	.
	64	1244	.	.	.	.	.	.
Prince Edward Bay	57	.	8550	10013	3658	.	.	.
	59	.	4718	.	.	.	.	.
	60	.	.	1536	.	.	.	.
	62	.	640	.	.	.	.	.
	67	.	1188	1463	.	.	.	.
South of Amherst	57	.	10882	14881	3347	3292	.	.
	59	.	.	.	1829	.	2378	.
	60	.	.	.	.	1097	.	.
	67	.	2286	.	.	.	.	.
Wellington	57	.	1829	3731	.	.	.	.
	67	.	2195	.	.	.	.	.
Brighton	57	.	1024	.	.	.	.	.
Total		5559	34958	33521	17888	8485	3384	5267

APPENDIX 2a. Weight and percent of species caught in Adolphus Reach in the five lifts sampled.

	Month							
	Apr		Sep		Oct		Dec	
Species	kg	%	kg	%	kg	%	kg	%
Rainbow Smelt	0.1	0	.	.	.	.	.	.
White Perch	0.9	4	1.4	7	4.6	3	.	.
Yellow Perch	13.6	67	13.6	63	113.4	83	15.4	44
Lake Whitefish	.	.	0.2	1	.	.	2.3	7
Common White Sucker	.	.	0.5	2	.	.	.	.
Brown Bullhead	.	.	0.5	2	1.4	1	0.2	1
Channel Catfish	.	.	1.1	5	.	.	.	.
Rock Bass	.	.	.	.	2.3	2	.	.
Pumpkinseed Sunfish	.	.	.	.	0.8	1	.	.
Crappie	.	.	.	.	0.2	0	.	.
Lake Herring	.	.	.	.	.	.	2.7	8
White Bass	.	.	.	.	.	.	0.9	3
Alewife	.	.	0.1	0	.	.	.	.
Gizzard Shad	.	.	0.5	2	0.6	0	.	.
Freshwater Drum	.	.	2.3	11	.	.	.	.
Fallfish	.	.	.	.	0.5	0	.	.
Brown Trout	0.9	4	.	.	0.4	0	1.8	5
Northern Pike	4.0	20	.	.	2.2	2	8.4	24
Walleye	0.9	4	1.3	6	7.9	6	2.2	6
Lake Trout	.	.	.	.	2.6	2	1.3	4

APPENDIX 2b. Weight and percent of species caught in the North Channel in the 23 lifts sampled.

	Month					
	Apr		Sep		Oct	
Species	kg	%	kg	%	kg	%
Common White Sucker	6.6	1	0.9	0	0.5	1
Brown Bullhead	1.1	0	.	.	0.2	0
White Perch	7.0	12	13.1	3	6.9	8
Rock Bass	10.0	2	40.8	9	6.9	8
Yellow Perch	519.4	79	365.2	76	46.0	53
Lake Herring	0.7	0	2.1	0	.	.
Rainbow Smelt	0.6	0	.	.	.	.
Lake Whitefish	0.5	0	2.1	0	1.8	2
Channel Catfish	.	.	16.4	3	1.4	2
Pumpkinseed Sunfish	.	.	0.1	0	.	.
White Bass	.	.	.	.	.	.
Long Nose Gar	8.2	1	.	.	.	.
Gizzard Shad	0.9	0	2.1	0	1.5	2
Trout-Perch	.	.	.	.	.	.
Sea Lamprey	0.9	0	.	.	.	.
Alewife	.	.	0.4	0	.	.
Freshwater Drum	.	.	.	.	1.4	2
Rainbow Trout	0.1	0	.	.	.	.
Brown Trout	2.9	0	1.3	0	1.4	2
Lake Trout	11.9	2	4.6	1	6.7	8
Northern Pike	16.6	3	0.9	0	1.9	2
Walleye	3.9	1	22.4	5	8.7	10
Smallmouth Bass	.	.	6.3	1	0.7	1
Chinook Salmon	.	.	0.1	0	.	.

APPENDIX 2b. (Concluded)

	Month			
	Nov		Dec	
Species	kg	%	kg	%
Common White Sucker	2.7	4	1.9	1
Brown Bullhead	.	.	.	.
White Perch	2.3	3	5.0	2
Rock Bass	.	.	0.2	0
Yellow Perch	59.0	77	179.1	86
Lake Herring	1.3	2	0.2	0
Rainbow Smelt	.	.	0.5	0
Lake Whitefish	5.6	7	2.1	1
Channel Catfish	.	.	.	.
Pumpkinseed Sunfish	0.9	1	.	.
White Bass	.	.	0.5	0
Long Nose Gar	.	.	.	.
Gizzard Shad	.	.	0.7	0
Trout-Perch	.	.	.	.
Sea Lamprey	.	.	.	.
Alewife	.	.	0.5	0
Freshwater Drum	.	.	0.7	0
Rainbow Trout	.	.	.	.
Brown Trout	.	.	0.4	0
Lake Trout	.	.	4.3	2
Northern Pike	1.8	2	2.3	1
Walleye	3.1	4	9.1	4
Smallmouth Bass	.	.	.	.
Chinook Salmon	.	.	.	.

APPENDIX 2c. Weight and percent of species caught in the area south of Amherst Island in the 28 lifts sampled.

	Month					
	Jul		Aug		Sep	
Species	kg	%	kg	%	kg	%
Lake Whitefish	13.6	2	.	.	.	.
White Perch	3.1	0	5.4	1	5.8	2
Rock Bass	49.3	6	31.4	3	16.6	5
Yellow Perch	687.0	84	787.4	85	281.7	80
Rainbow Smelt	0.1	0	0.1	0	0.5	0
Common White Sucker	0.1	0	2.3	0	1.8	1
Lake Herring	.	.	0.7	0	2.3	1
Brown Bullhead	.	.	11.3	1	.	.
Channel Catfish	.	.	8.5	1	4.1	1
Pumpkinseed Sunfish	.	.	0.1	0	.	.
Crappie	.	.	0.1	0	.	.
Long Nose Sucker	.	.	1.8	0	.	.
Burbot	.	.	.	.	.	.
Alewife	31.1	4	7.9	1	0.5	0
Trout-Perch	0.3	0	0.2	0	.	.
Freshwater Drum	.	.	5.9	1	1.4	0
Gizzard Shad	.	.	.	.	5.5	2
Lake Trout	7.2	1	7.8	1	4.8	1
Smallmouth Bass	20.6	3	41.2	4	8.6	2
Walleye	8.1	1	11.9	1	17.3	5
Brown Trout	1.0	0	0.1	0	.	.
Northern Pike	.	.	0.6	0	.	.
Chinook Salmon	.	.	.	.	0.1	0

APPENDIX 2c. (Concluded)

	Month			
	Oct		Nov	
Species	kg	%	kg	%
Lake Whitefish	3.4	1	11.4	17
White Perch	4.6	1	0.1	0
Rock Bass	6.0	1	2.8	4
Yellow Perch	366.5	87	46.2	69
Rainbow Smelt	.	.	0.1	0
Common White Sucker	0.2	0	.	.
Lake Herring	3.4	1	0.1	0
Brown Bullhead	.	.	.	.
Channel Catfish	2.3	1	.	.
Pumpkinseed Sunfish	.	.	.	.
Crappie	.	.	.	.
Long Nose Sucker	.	.	.	.
Burbot	.	.	0.5	1
Alewife	.	.	0.1	0
Trout-Perch	.	.	.	.
Freshwater Drum	.	.	.	.
Gizzard Shad	1.4	0	.	.
Lake Trout	0.4	0	0.8	1
Smallmouth Bass	6.4	2	.	.
Walleye	24.1	6	5.0	7
Brown Trout	0.4	0	.	.
Northern Pike	.	.	.	.
Chinook Salmon	.	.	.	.

APPENDIX 2d. Weight and percent of species caught in Prince Edward Bay in the 22 lifts sampled.

	Month					
	Jul		Aug		Sep	
Species	kg	%	kg	%	kg	%
Lake Herring	1.3	0	2.8	1	0.5	0
American Eel	1.8	0	.	.	.	.
White Perch	14.4	3	2.2	1	.	.
White Bass	4.1	1	0.2	0	0.2	0
Rock Bass	66.5	12	6.5	2	4.1	4
Yellow Perch	364.3	64	240.5	63	58.9	58
Common White Sucker	36.2	6	83.5	22	24.9	25
Lake Whitefish	0.5	0	.	.	.	.
Burbot	1.8	0	.	.	.	.
Channel Catfish	.	.	1.2	0	.	.
Brown Bullhead	.	.	3.6	1	.	.
Pumpkinseed Sunfish	.	.	1.8	0	.	.
Alewife	49.0	9	7.6	2	1.1	1
Freshwater Drum	5.9	1	0.5	0	.	.
Gizzard Shad	.	.	0.2	0	.	.
Northern Pike	9.3	2	5.3	1	0.6	1
Smallmouth Bass	4.2	1	5.3	1	0.3	0
Walleye	9.3	2	14.9	4	6.5	6
Lake Trout	2.6	0	1.8	0	4.0	4
Brown Trout	0.4	0	1.7	0	.	.
Chinook Salmon	.	.	1.7	0	0.1	0
Rainbow Trout	.	.	0.9	0	.	.

APPENDIX 2e. Weight and percent of species caught in Wellington in the six lifts sampled.

	Month			
	Jul		Aug	
Species	kg	%	kg	%
Common White Sucker	4.3	2	5.2	4
Brown Bullhead	4.5	2	.	.
White Perch	2.9	1	1.1	1
White Bass	1.9	1	.	.
Rock Bass	12.5	6	3.0	3
Yellow Perch	178.6	85	100.9	86
Lake Herring	0.2	0	0.5	0
Alewife	3.8	2	0.9	1
Stonecat	0.2	0	.	.
Gizzard Shad	.	.	0.9	1
Lake Trout	0.4	0	0.9	1
Smallmouth Bass	0.2	0	.	.
Brown Trout	0.4	0	0.9	1
Walleye	.	.	3.5	3

APPENDIX 3. Weight caught (kg) in each area and month by species group.

Area & Group	Apr	Jul	Aug	Sep	Oct	Nov	Dec
Adolphus Reach							
Other	.	.	.	2.9	1.1	.	.
Yellow Perch	13.6	.	.	13.6	113.4	.	15.4
Commercial	1.0	.	.	3.7	9.3	.	6.1
Sport	5.7	.	.	1.3	13.2	.	13.7
Total	20.3	.	.	21.5	137.0	.	35.2
North Channel							
Other	10.0	.	.	2.5	2.9	.	1.9
Yellow Perch	519.4	.	.	365.2	46.0	59.0	179.1
Commercial	96.5	.	.	75.5	17.7	12.8	10.4
Sport	35.4	.	.	35.6	19.4	4.8	16.2
Total	661.3	.	.	478.7	86.0	76.6	207.6
South Amherst							
Other	.	31.4	14.0	7.4	1.4	0.1	.
Yellow Perch	.	687.0	787.4	281.7	366.5	46.2	.
Commercial	.	66.2	61.7	31.1	19.9	15.0	.
Sport	.	36.9	61.6	30.8	31.4	5.7	.
Total	.	821.5	924.7	351.0	419.2	67.0	.
Pr. Ed. Bay							
Other	.	54.9	8.3	1.1	.	.	.
Yellow Perch	.	364.3	240.5	58.9	.	.	.
Commercial	.	126.6	101.8	29.7	.	.	.
Sport	.	25.8	31.4	11.5	.	.	.
Total	.	571.6	382.0	101.2	.	.	.

APPENDIX 3. (Continued)

Area and Group	Apr	Jul	Aug	Sep	Oct	Nov	Dec
	Month						
Wellington							
Other	.	4.0	1.8	.	.	.	.
Yellow Perch	.	178.6	100.9	.	.	.	.
Comm	.	26.3	9.8	.	.	.	.
Sport	.	1.1	5.3	.	.	.	.
Total	.	210.0	117.8	.	.	.	.
Brighton							
Other	.	0.1	.	.	.	.	.
Yellow Perch	.	0.3	.	.	.	.	.
Total	.	0.4	.	.	.	.	.
Monthly Totals:							
Other	10.0	90.4	24.1	13.9	5.4	0.1	1.9
Yellow Perch	533.0	1230.2	1128.8	719.4	525.9	105.2	194.5
Commercial	97.5	219.1	173.3	140.0	46.9	27.8	16.5
Sport	41.1	63.8	98.2	79.2	64.0	10.6	29.8
Grand Total	681.6	1603.4	1424.4	952.5	642.2	143.7	242.7

Area Totals:	AR	NC	PEB	SA	WEL	B
Other	4.0	17.3	64.3	54.3	5.8	0.1
Yellow Perch	156.0	1168.7	663.7	2168.8	279.5	0.3
Commercial	20.1	212.9	258.1	193.9	36.1	.
Sport	33.9	111.3	68.6	166.4	6.4	.
Total	214.0	1510.2	1054.7	2583.4	327.8	0.4

APPENDIX 3. (Concluded)

Group Totals:

Other	136.7
Yellow Perch	4437.0
Commercial	721.1
Sport	386.7
Total	5690.5

APPENDIX 4. Weight caught (kg) summarized by group. Commercial fishermen may wish to employ alternate gear types or fishing techniques in time/area situations where sport fish comprise a large fraction of the catch of the target species, in this case, yellow perch.

Month	Grid	Comm	Other	Sport	Yellow Perch
Apr	1239	96.5	0.9	35.4	519.4
	1337	1.0	.	5.7	13.6
Jul	1240	8.5	3.7	2.6	63.5
	1337	31.0	7.7	8.8	167.8
	1338	5.9	4.5	6.2	90.7
	1339	12.6	9.0	11.1	226.7
	1340	39.2	14.2	17.0	306.1
	1437	26.9	14.1	3.4	46.3
	1528	.	0.1	.	0.3
	1536	63.7	32.6	12.2	149.2
	1537	5.0	0.5	1.3	1.0
	1632	18.6	2.3	0.7	95.3
	1633	7.7	1.7	0.4	83.3
Aug	1240	23.5	8.9	20.8	122.6
	1338	20.8	0.1	13.0	45.4
	1340	5.1	2.4	13.7	267.8
	1341	12.3	2.6	14.1	351.6
	1535	80.2	0.1	8.5	66.8
	1536	14.6	7.9	8.8	172.4
	1537	7.0	0.3	14.1	1.3
	1632	7.7	1.8	5.3	90.7
	1633	2.1	.	.	10.2
Sep	1239	59.3	1.7	23.6	329.0
	1240	15.5	0.5	10.4	18.1
	1337	3.7	2.9	1.3	13.6
	1338	9.8	0.8	4.5	145.1
	1340	19.6	6.4	13.8	79.4
	1341	2.1	.	7.8	45.4
	1438	0.3	0.5	6.4	29.9
	1536	29.7	1.1	11.5	58.9

Appendix 4. (Concluded)

Oct	1238	7.5	1.0	5.9	14.2
	1239	7.0	1.4	2.6	22.7
	1240	3.2	0.5	10.8	9.1
	1338	7.8	0.5	5.0	26.3
	1340	7.5	.	15.3	226.8
	1341	4.6	0.9	11.1	113.4
	1436	9.3	1.1	13.2	113.4
Nov	1239	2.5	.	1.5	22.7
	1338	15.0	0.1	5.7	46.2
	1435	10.3	.	3.3	36.3
Dec	1239	1.1	0.1	4.0	117.9
	1337	6.1	.	13.7	15.4
	1435	5.1	0.1	3.4	18.1

APPENDIX 5a. Estimated catch of sport fish species in the North Channel.

Species	Apr %	Apr kg	Sep %	Sep kg	Oct %	Oct kg
Yellow Perch	79.64	6508	76.28	5313	53.50	3580
Rainbow Trout	0.02	2	.	0	.	0
Brown Trout	0.44	36	0.28	20	1.67	112
Lake Trout	1.82	149	0.97	68	7.81	523
Northern Pike	2.55	208	0.18	13	2.18	146
Walleye	0.59	48	4.67	325	10.12	677
Smallmouth Bass	.	0	1.31	91	0.77	52
Chinook Salmon	.	0	0.02	1	.	0
Total kg		443		518		1510

Species	Nov %	Nov kg	Dec %	Dec kg	Total kg
Yellow Perch	76.98	1157	86.28	1420	17978
Rainbow Trout	.	0	.	.	2
Brown Trout	.	0	0.21	3	171
Lake Trout	.	0	2.07	34	774
Northern Pike	2.30	35	1.11	18	420
Walleye	4.02	60	4.40	72	1182
Smallmouth Bass	.	0	.	.	143
Chinook Salmon	.	0	.	.	1
Total kg		95		127	2693

APPENDIX 5b. Estimated incidental catch of sport fish species in Adolphus Reach (excludes November, fishing was reported but no samples were collected).

Species	Apr %	Apr kg	Sep %	Sep kg	Oct %	Oct kg
Yellow Perch	66.91	1318	63.19	16	82.76	1341
Brown Trout	4.33	85	.	0	0.32	5
Northern Pike	19.51	384	.	0	1.61	26
Walleye	4.33	85	6.14	2	5.79	94
Lake Trout	.	0	.	0	1.93	31
Total kg		554		2		156

Species	Dec %	Dec kg	Total kg
Yellow Perch	43.80	229	2904
Brown Trout	5.01	26	116
Northern Pike	23.81	125	535
Walleye	6.27	33	214
Lake Trout	3.76	20	51
Total kg		204	916

APPENDIX 5c. Estimated incidental catch of sport fish species for the area south of Amherst Island (excludes April and December when fishing occurred but no samples were collected).

	Month										
	Jul		Aug		Sep		Oct		Nov		Total
Species	%	kg	%	kg	%	kg	%	kg	%	kg	kg
Yellow Perch	83.63	7748	85.16	5838	80.25	3783	87.43	7725	68.93	1808	26902
Brown Trout	0.12	11	0.01	1	.	0	0.11	10	.	0	22
Lake Trout	0.87	81	0.85	58	1.38	65	0.11	10	1.15	30	244
Northern Pike	.	0	0.06	4	.	0	.	0	.	0	4
Walleye	0.99	92	1.29	88	4.93	232	5.75	508	7.39	194	1114
Smallmouth Bass	2.51	233	4.45	305	2.45	116	1.52	134	.	0	788
Chinook Salmon	.	0	.	0	0.03	1	.	0	.	0	1
Total kg		417		456		414		662		224	2173

APPENDIX 5d. Estimated incidental catch of sport fish species in Prince Edward Bay (excludes April and October to December as no samples were collected even though fishing was reported).

	Month			
	Jul		Aug	
	%	kg	%	kg
Yellow Perch	63.74	3637	62.96	2734
Rainbow Trout	.	0	0.23	10
Brown Trout	0.08	5	0.43	19
Lake Trout	0.46	26	0.46	20
Northern Pike	1.62	92	1.38	60
Walleye	1.62	92	3.89	169
Smallmouth Bass	0.73	42	1.38	60
Chinook Salmon	.	0	0.43	19
Total kg		257		173

	September		Total
	%	kg	kg
Yellow Perch	58.23	1515	7886
Rainbow Trout	.	0	10
Brown Trout	.	0	24
Lake Trout	3.92	102	148
Northern Pike	0.54	14	166
Walleye	6.42	167	428
Smallmouth Bass	0.33	9	111
Chinook Salmon	0.11	3	22
Total kg		295	909

APPENDIX 5e. Estimated incidental catch of sport fish species in the Wellington area (September excluded as fishing reported but no samples collected).

	Month				
	Jul		Aug		Total
Species	%	kg	%	kg	kg
Yellow Perch	85.05	4104	85.66	2143	6247
Brown Trout	0.21	10	0.75	19	29
Lake Trout	0.21	10	0.75	19	29
Walleye	.	0	2.99	75	75
Smallmouth Bass	0.10	5	.	0	5
Total kg		25		113	138

Great Lakes Fishery Commission
Lake Ontario Committee Meeting
March 21-22, 1989
Buffalo, New York

EXPLORATORY OUTBOARD TRAWLING IN NEARSHORE HABITAT OF EASTERN LAKE ONTARIO AND THE BAY OF QUINTE

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ABSTRACT

Potential sampling areas were chosen in Lake Ontario, Wellers Bay, West Lake, and the Bay of Quinte. Where possible, areas were stratified into two depths (shallow: 2-3 m; deep: 4-6 m). Most areas were sampled during August 1988 and a subset were sampled again during September. Thirty-three species of fish were captured. The most abundant species were alewife, gizzard shad, white sucker, spottail shiner, trout-perch, white perch, pumpkinseed, yellow perch, walleye, and johnny darter. Tows during September in Lake Ontario caught very few fish of any species relative to samples during August in the same area. However, in the Bay of Quinte, only alewife were found to differ significantly between August and September. Alewife were absent from most of these areas during August, but were found at six of the ten Bay of Quinte areas that were sampled in September. Other than young-of-year yellow perch and trout-perch, most fish showed no significant trends in depth. Too few replicates were collected to resolve catch differences between areas, other than presence-absence differences. The optimum number of tows at an area to determine the year-to-year differences in fish populations was found to be three, and this would provide a detection level of 37% to determine a significant difference. For cases where the same location was sampled twice on the same day, the first tow reduced the catch of the second tow.

RECOMMENDATATIONS

1. Future outboard trawling should be limited to August in Lake Ontario, but could occur in August or September in the Bay of Quinte.

2. Further exploration of habitat is required to find index sites for other species such as smallmouth bass.

3. Develop a suitable index of year-class strength for yellow perch using yearlings.

4. Treat 3-5 m as one depth zone and take all samples from this depth.

5. At least one hour should be taken between successive trawls at the same location.

6. Three replicates should be taken in each sampling area.

7. Develop and employ a method for assessing the quantity of aquatic vegetation when trawling.

INTRODUCTION

Relatively little information exists on distribution and abundance of small fishes in the nearshore habitats of Lake Ontario and the Bay of Quinte. Such information is used for predicting year class strength in various fish populations before the year-class is recruited to a fishery. Although some data is available from electrofishing and the current research trawl programs, too few samples are collected from too few habitats. These programs require considerable time and effort to collect fish. Moreover, they do not sample the littoral zone from 2 to 6 m, which is occupied by young-of-year (YOY) of many important species, and by warmwater forage species. Outboard trawling fits the requirements for sampling small fish in such habitats because the gear is efficient yet highly mobile, thereby allowing the sampling of a relatively large number of habitats and locations over a short period of time.

This program was intended to explore the use of outboard trawling gear and provide a frame survey to index the abundance of juvenile walleye, yellow perch, and juveniles and adults of other species that are found in nearshore habitats. This information complements our gillnet, and large trawl programs which sample different portions of the fish community by virtue of gear selectivity and the habitats and locations that are sampled.

In this first season the program assessed the types and locations of habitat that could be adequately sampled, and the temporal and depth variation in abundance of fish species. Results will be used to choose sites to index small fish abundance in these habitats.

PROCEDURES

Potential sampling areas were chosen in Lake Ontario, Wellers Bay, West Lake, and the Bay of Quinte (Figure 1). More precise descriptions of the location of these areas are found in Bowlby (1988). Where possible, areas were stratified into two depths (shallow: 2-3 m; deep: 4-6 m).

Most areas were sampled during August 1988 to complement existing trawl and index programs. Earlier sampling would not be suitable because YOY would be too small to capture. A subset of areas were sampled again during September 1988. Some of these areas were unsuitable for outboard trawling because of excessive aquatic vegetation, depth, or substrate. All trawling was done during daylight hours.

Tows were 6 minutes at a speed of 3 km/h (1.86 mph) for a distance of 300 m. A few tows were cut short because of unsuitable bottom. Each depth stratum was sampled twice by either trawling over the same area or by continuing on from the end point of the first trawl. All catches were standardized to number of fish caught per hour for each species. In addition, walleye, white perch, and yellow perch were grouped by life stage (YOY and older fish) for analytical purposes.

The trawl had an opening of approximately 4 foot square. The net mesh was 1 inch (stretched) and the cod end mesh was one-half inch (stretched).

The required number of replicates to detect a difference in catch per effort (CPE) of a species from one year to the next using Analysis of Variance (ANOVA) was calculated following Sokal and Rohlf (1981:262). The number of replicates required to detect such a difference is dependent on the coefficient of variation (CV) of CPE of a species, the power of the test, the significance level, and the smallest true difference that is desired to detect. The power of the test was set to 0.8, and the significance level to 0.05. As well, we assumed that a species would be found at 10 areas and that year-area interactions would not be significant.

Month, area, and depth effects of CPE were examined with ANOVA and Tukey's studentized range test using the GLM procedure of SAS (Joyner 1985). The level of significance was 0.05. ANOVA was performed on $\log_e$(CPE+1) data.

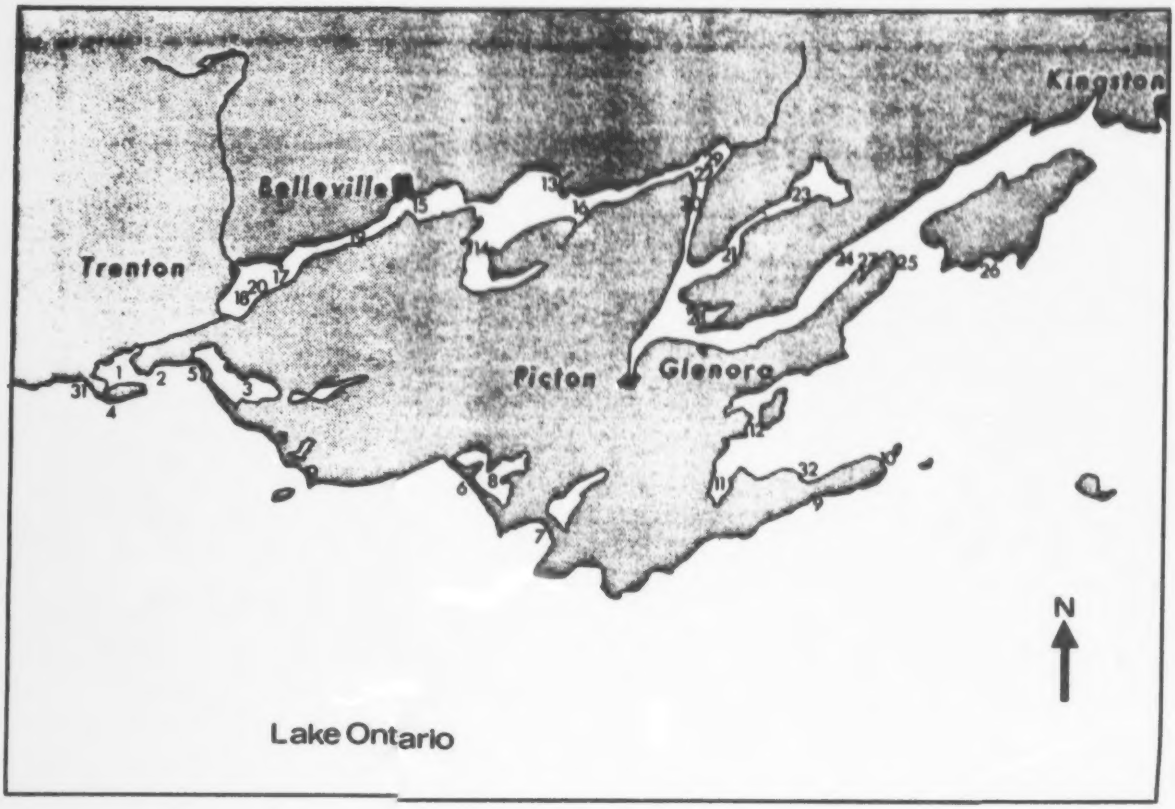
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Figure 1. Map showing location of sampling areas during 1988. Area numbers are listed in Table 1.

Table 1. A list of areas that were intended for sampling by outboard trawl during 1988. See Figure 1.

Area number	Location
1	Presquile Bay
2	Middle Ground
3	Wellers Bay
4	Owen Point
5	Barcovan Beach
6	Wellington Bay
7	Athol Bay
8	West Lake
9	Big Sands Bay
10	Long Point
11	South Bay
12	Morrison Point
13	Hungry Bay
14	Muscote Bay
15	Belleville - east of Harbour
16	Northport
17	Baker Island
18	Indian Island
19	East of Maketewis Island
20	Onderdonk Point
21	Hay Bay - south of Ram Island
22	Foresters Island
23	Hay Bay
24	Conway
25	Indian Point
26	East of Grape Island
27	East of Prinyer Cove
28	Carnachan Bay
29	Mohawk Bay
30	Coles Wharf
31	Popham Bay
32	Flatt Point

RESULTS AND DISCUSSION

UNSUITABLE SAMPLING AREAS

Some areas were left unsampled or attempts at sampling failed as a result of rocks, debris, and submerged aquatic vegetation (Table 2). Those areas where attempts failed or were judged unsuitable will not be considered as future index stations.

Aquatic vegetation has the ability to close off the mouth of the trawl and thereby reduce the CPE. On the other hand, aquatic vegetation might attract fish and increase the CPE. We should develop and employ a method for assessing the quantity of aquatic vegetation when trawling to determine if habitat changes might be the cause of changes in CPE as opposed to changes in fish populations.

Table 2. Areas that were not sampled or where trawling attempts failed and reasons for failure.

Area[a]	Sample attempted	Comments
1	Yes	- net filled with vegetation.
3	Yes (September)	- unable to cross sandbar at mouth of Weller's Bay due to low water.
4	No	- too rocky.
10	Yes	- 2nd trawl got hung up on bottom.
15 (2 m)	Yes	- caught metal debris.
16	No	- lack of time; should try in 1989.
19	No	- lack of time; should try in 1989.
22 (2.5 m)	Yes	- net filled with bark.
24	No	- too deep.
25	Yes	- too rocky.
27	No	- too much man-made debris.
28 (2 m)	Yes	- net filled with vegetation.
32	No	- too rocky.

[a] - parentheses indicate failures at that depth only.

FISH SPECIES CAPTURED

Thirty-three species of fish were captured (Table 3). The most abundant species were alewife, gizzard shad, white sucker, spottail shiner, trout-perch, white perch, yellow perch, walleye, and johnny darter (Tables 4, 5). Further analyses were confined to these species. In addition, white perch, yellow perch and walleye were stratified into two life stage groups: 1) YOY, and 2) older fish.

Table 3. Fish species captured in the Outboard Trawl Program in eastern Lake Ontario during 1988.

Code	Common name	Scientific name
051	Bowfin	*Amia calva*
061	Alewife	*Alosa pseudoharengus*
063	Gizzard shad	*Dorosoma cepedium*
121	Rainbow smelt	*Osmerus mordax*
131	Northern pike	*Esox lucius*
163	White sucker	*Catostomus commersoni*
186	Common carp	*Cyprinus carpio*
196	Emerald shiner	*Notropis atherinoides*
201	Spottail shiner	*Notropis hudsonius*
204	Sand shiner	*Notropis stramineus*
208	Bluntnose minnow	*Pimephales notatus*
232	Yellow bullhead	*Ictalurus natalis*
233	Brown bullhead	*Ictalurus nebulosus*
234	Channel catfish	*Ictalurus punctatus*
251	American eel	*Anguilla rostrata*
271	Burbot	*Lota lota*
281	Brook stickleback	*Culea inconstans*
291	Trout-perch	*Percopsis omiscomaycus*
301	White perch	*Morone americana*
302	White bass	*Morone chrysops*
311	Rock bass	*Ambloplites rupestris*
313	Pumpkinseed	*Lepomis gibbosus*
314	Bluegill	*Lepomis macrochirus*
316	Smallmouth bass	*Micropterus dolomieui*
317	Largemouth bass	*Micropterus salmoides*
319	Black crappie	*Pomoxis nigromaculatus*
331	Yellow perch	*Perca flavescens*
334	Walleye	*Stizostedion vitreum*
341	Johnny darter	*Etheostoma nigrum*
342	Logperch	*Percina caprodes*
371	Freshwater drum	*Aplodinotus grunniens*
381	Mottled sculpin	*Cottus bairdi*
382	Slimy sculpin	*Cottus cognatus*

Table 4. Mean catch per effort (number/hour) for each species at each area sampled during August. Species codes are identified in Table 3. Letters at the end of species codes refer to life stage group as follows: A - yearlings and older; Y - young-of-year.

	Species																
Area	061	063	131	163	186	196	201	204	208	232	233	234	251	291	301A	301Y	302
2	.	.	.	.	.	.	5.0	.	.	.	.	.	.	.	41.7	2.5	.
3	.	.	.	40.0	.	.	.	.	.	.	.	.	.	.	.	.	.
5	2.5	.	.	.	.	.	155.0	.	.	.	.	.	.	.	.	.	.
6	35.0	.	.	.	.	.	.	.	.	.	.	.	.	2.5	.	.	.
7	42.5	.	.	.	.	20.0	312.5	.	.	.	.	.	.	17.5	.	.	.
8	.	.	5.0	.	.	.	20.0	5.0	145.0	.	.	.	.	.	.	.	.
9	420.0	.	.	.	.	.	1640.0	.	.	.	.	.	.	5.0	.	.	.
10	.	.	.	.	.	.	44.8	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	13.3	3.3	.	.	3073.3	63.3	.
14	.	.	.	60.0	.	.	280.0	.	.	.	10.0	.	10.0	360.0	.	340.0	.
15	.	4.0	2.0	14.0	.	.	34.0	.	.	.	8.0	.	4.0	61.0	6.3	200.6	.
17	.	163.3	.	16.7	.	.	356.7	.	.	.	20.0	.	3.3	616.7	.	5993.3	.
18	.	45.0	.	35.0	.	.	375.0	.	.	.	20.0	.	.	720.0	.	2065.0	.
20	.	140.0	.	30.0	.	.	200.0	.	.	.	10.0	.	5.0	1010.0	.	3090.0	30.0
21	.	.	.	.	.	.	220.0	.	.	.	.	.	20.0	370.0	45.0	130.0	.
22	.	.	.	.	.	.	56.7	.	.	.	6.7	.	3.3	13.3	43.3	.	.
23	.	2.5	.	.	5.0	.	435.0	.	.	2.5	37.5	2.5	7.5	172.5	235.0	777.5	.
26	.	.	.	.	.	.	5.0	.	.	.	.	.	.	47.5	.	.	.
28	90.0	.	2.5	.	.	.	.	.	.	.	.	.	.	15.0	37.5	.	.
29	.	.	.	.	.	.	13.4	.	.	.	53.7	.	10.1	267.4	57.2	103.9	3.3
30	50.0	.	.	.	.	.	560.0	.	.	.	.	.	30.0	70.0	20.0	90.0	10.0
31	5.0	.	.	.	.	.	.	.	.	.	.	.	5.0	.	.	.	.

Table 4 Continues

Table 4 (Concluded)

	Species														
Area	311	313	314	316A	316Y	317A	317Y	319	331A	331Y	334A	334Y	341	342	371
2	.	.	.	.	.	3.8	5.0	.	32.5	420.8	.	.	16.3	.	.
3	.	140.0	.	25.0	.	.	.	.	.	50.0	5.0	.	.	.	.
5	.	.	.	.	.	.	.	.	77.5	300.0	2.5	.	17.5	.	.
6	.	.	.	.	.	.	.	.	220.0	30.0	.	.	.	.	.
7	.	.	.	.	.	.	.	.	327.5	1875.0	.	.	.	.	.
8	25.0	490.0	.	.	.	.	10.0	.	100.0	100.0	.	.	.	.	.
9	.	.	.	5.0	60.0	.	.	.	.	.	.	.	15.0	.	.
10	14.9	.	.	.	104.5	.	.	.	.	.	.	.	14.9	.	.
12	.	5.0	.	.	.	.	.	.	185.0	20.0	.	.	.	.	.
13	.	200.0	.	3.3	.	.	.	6.7	86.7	.	10.0	.	.	.	20.0
14	.	120.0	.	.	.	.	.	.	270.0	3710.0	.	70.0	.	.	.
15	.	36.0	.	.	.	.	.	10.0	209.0	50.7	8.7	24.0	.	2.3	8.0
17	.	66.7	.	.	.	.	.	3.3	1626.7	133.3	3.3	53.3	.	.	.
18	5.0	15.0	5.0	5.0	.	.	5.0	5.0	1970.0	75.0	35.0	30.0	.	.	.
20	.	.	.	.	.	.	.	5.0	420.0	80.0	10.0	40.0	10.0	.	.
21	.	.	.	.	.	.	.	.	295.0	635.0	30.0	15.0	.	.	.
22	.	.	.	.	.	.	.	.	13.3	.	3.3	.	.	.	3.3
23	.	7.5	.	.	.	.	.	.	192.5	162.5	20.0	40.0	.	.	.
26	.	.	.	.	17.5	.	.	.	.	.	2.5	.	10.0	.	.
28	.	110.0	.	.	.	.	.	.	1350.0	85.0	12.5	15.0	.	.	.
29	.	.	.	.	.	.	.	.	67.0	43.4	.	10.0	.	.	.
30	.	.	.	.	.	.	.	.	130.0	20.0	10.0	20.0	.	.	.
31	.	.	.	.	.	.	.	.	5.0	.	.	.	55.0	.	.

Table 5. Mean catch per effort (number/hour) for each species at each area sampled during September. Species codes are identified in Table 3. Letters at the end of species codes refer to life stage group as follows: A - yearlings and older; Y - young-of-year.

	Species																
Area	051	061	063	121	131	163	186	201	233	271	281	291	301A	301Y	302	311	313
5	.	7.5	.	2.5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	2.5	.	.	.	.	.	10.0	.	.	.	.	.	.	.	.	.
8	.	5.0	5.0	.	10.0	5.0	5.0	235.0	5.0	.	.	.	120.0	635.0	.	10.0	145.0
11	.	.	.	.	.	.	.	.	.	.	3.3	.	.	.	.	16.7	50.0
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	500.0
13	.	2.5	2.5	.	.	2.5	.	110.0	.	.	.	15.0	35.0	105.0	.	.	15.0
14	.	30.0	.	.	.	10.0	.	285.0	10.0	.	.	540.0	10.0	1565.0	.	.	.
15	.	25.0	30.0	.	.	10.0	.	155.0	10.0	.	.	625.0	.	790.0	.	.	15.0
17	.	70.0	.	.	.	10.0	.	350.0	.	.	.	610.0	.	1420.0	.	.	60.0
18	.	30.0	25.0	.	.	.	5.0	560.0	40.0	.	.	370.0	.	3745.0	.	.	80.0
20	.	35.0	20.0	.	.	5.0	.	185.0	.	.	.	550.0	.	5000.0	.	.	90.0
21	.	5.0	.	.	.	10.0	.	535.0	5.0	.	.	335.0	20.0	155.0	.	.	.
22	.	.	.	.	.	.	.	20.0	.	.	.	.	15.0	90.0	.	.	.
23	2.5	.	15.0	.	2.5	7.5	5.0	.	47.5	.	.	177.5	100.0	120.0	2.5	.	10.0
29	.	.	.	.	.	.	5.0	70.0	45.0	65.0	.	95.0	15.0	625.0	5.0	.	95.0
30	.	.	45.0	.	.	10.0	.	625.0	.	.	.	95.0	.	55.0	.	.	15.0
31	.	12.5	.	2.5	.	.	.	95.0	.	.	.	7.5	.	.	.	.	.

Table 5 Continues

Table 5 (Concluded)

	Species													
Area	314	316A	317A	317Y	319	331A	331Y	334A	334Y	341	342	371	381	382
5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	75.0	1090.0		.	.	.	.	.	.
8	.	.	20.0	5.0	.	335.0	300.0	15.0	.	.	5.0	.	.	.
11	.	.	.	.	.	493.3	.	.	.	6.7	.	.	3.3	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	5.0	.	.	.	5.0	.	45.0	5.0	.	.	.	.	.
14	.	5.0	.	.	.	185.0	115.0	45.0	20.0	.	.	30.0	.	.
15	.	.	.	.	.	60.0	10.0	10.0	15.0	.	.	.	.	.
17	.	.	.	.	10.0	520.0	70.0	20.0	20.0	.	.	.	.	.
18	35.0	.	.	.	.	2110.0	50.0	5.0	30.0	.	.	.	.	.
20	.	.	.	.	.	3005.0	105.0	.	35.0	.	.	25.0	.	.
21	.	.	.	.	.	305.0	120.0	10.0	15.0	.	.	.	.	.
22	.	.	.	.	.	20.0	.	10.0	10.0	.	.	15.0	.	.
23	.	.	.	.	.	145.0	17.5	20.0	2.5	.	.	2.5	.	.
29	.	.	.	.	.	245.0	10.0	20.0	.	.	.	.	.	.
30	.	.	.	.	.	845.0	570.0	20.0	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	2.5	.	.	.	2.5

MONTH COMPARISONS

Results of ANOVA of CPE for month, depth, and area are detailed in Bowlby (1989). The more important results are summarized below.

In the three-way ANOVA of CPE for these effects the month-area interaction was significant for almost all species. This was because tows during September in Lake Ontario caught very few fish of any species relative to samples during August in the same area. Most of the these tows in September resulted in no catch of any species. The reasons for these low catches are unclear, but may have been a response to water temperatures or predators. Water temperatures were lower and numerous lake trout were caught in our nearby trapnets in the same depth of water (LOFU, unpublished data). However, in the Bay of Quinte, only alewife were found to differ significantly ($F=20.46$, $p<0.0001$) between August and September. Alewife were absent from most of these areas during August (Table 4), but were found at 6 of the ten Bay of Quinte areas that were sampled in September (Table 5).

Accordingly, future outboard trawling should be limited to August in Lake Ontario, but could occur in August or September in the Bay of Quinte. Moreover, if an index of alewife is desired for the Bay of Quinte then September is the preferred month. Once a decision is made to sample an area in a particular month then that area should subsequently be sampled only in that month.

DEPTH COMPARISONS

The CPE of YOY yellow perch was significantly greater ($F=8.78$, $p<0.008$) at shallow depths (2-3 m) during August, but there was no difference in September. YOY yellow perch appeared to be associated with the areas of abundant aquatic vegetation which was also more abundant in shallow water. We had difficulty sampling such areas and therefore feel this program may not provide an adequate index of YOY yellow perch. However, yearling yellow perch made up the greatest portion of the remainder of the yellow perch catch, and they appeared to show less association with the shallow areas containing aquatic vegetation. Accordingly, a suitable index of year-class strength for yellow perch could be developed using yearlings.

Trout-perch were found to be significantly more abundant ($F=11.66$, $p<0.006$) at deep depths (4-6 m) during September. However, most of this variation can be traced to differences in depth distribution at area 23.

Other species showed no significant trends in depth during August or September. Accordingly, we can treat the shallow and deep zones as one homogeneous habitat. However, to be conservative we should take all future samples from the 3-5 m depth zone.

AREA COMPARISONS

Although significant differences in CPE for a given species between areas were detected, most of these differences can be simply summed up as presence-absence differences (Bowlby 1989). That is, areas with zero catch in all replicates were significantly different than areas with some catch in all replicates. A few exceptions to this rule were noted but generally were due to a lower number of replicates for each area. More replicates are required if area comparisons are desired. These additional replicates might be obtained through several years of sampling after which area comparisons could be made with more resolution.

SAMPLE SIZE REQUIREMENTS

For this program we were concerned primarily with detecting differences in species abundance from one year to the next. The smallest percent true difference between mean CPEs that could be detected from one year to the next (D), across all areas was calculated for trawl replicates numbering from 2 to 6 (Table 6). Because this was the first year for the program, we have no knowledge of the year-to-year variation that might be expected. Accordingly, the choice of sample size based on D will be somewhat arbitrary. However, the improvement in precision with increasing sample size is a decreasing function, such that the best improvement (10%) in D occurs from sample size 2 to 3 (Table 6). From sample size 3 to 4, D improves by only 5%. In my judgement three replicates per area would optimize the desired level of precision with the cost of additional sampling.

Table 6. The effect of sample size (number of tows) at an area on the smallest percent true difference between mean CPEs that can be detected from one year to the next, across areas.

Sample size	Smallest % difference that can be detected (D)
2	47
3	37
4	32
5	28
6	26

TIME BETWEEN REPLICATES

For cases where the same location was sampled twice on the same day there was sometimes a substantial decline in CPE between the first and second tow. This decline was thought to result from an effect of the first on the second tow. To test for this effect data for species which occurred at more than 5 area-month-depth strata was used. A significant number of species (11 of 14, Table 7) showed a negative correlation between the variability of the catch (CV of CPE) and the time between tows ($G=4.86$, $p<0.05$, G test for homogeneity of these signs). Moreover, these negative relationships were statistically significant for yellow perch adults and white suckers (Table 7). None of the three positive relationships were statistically significant. For most species the CV of CPE was typically near 50% as the time between replicates approached one hour (e.g. Figure 2). Accordingly, at least one hour should be taken between successive trawls at the same location. Moreover, if sampling occurred on separate days then it would be highly unlikely to have such effects.

Table 7. Correlations between the variability of the catch (CV of CPE) and the time between tows for a number of species caught in outboard trawl during 1988.

Species code	r	p[a]	n
061	-0.058	0.441	9
063	-0.041	0.448	13
163	-0.724	0.002	14
201	-0.285	0.119	19
233	-0.005	0.493	16
251	0.373	0.705	7
291	-0.297	0.109	19
301A	-0.154	0.317	12
301Y	-0.176	0.235	19
313	-0.020	0.472	15
331A	-0.442	0.020	22
331Y	-0.122	0.290	23
334A	0.249	0.653	19
334Y	0.252	0.683	15

[a] - one-tailed test.

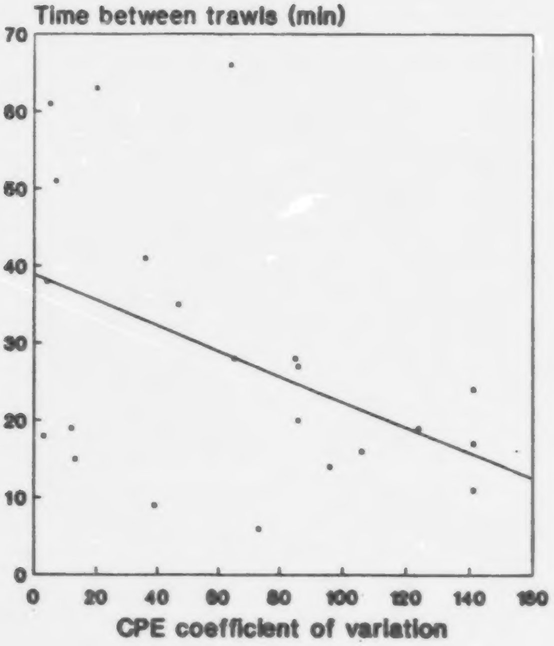

Figure 2. The relationship of time between tows and coefficient of variation of catch per effort for adult yellow perch.

CONCLUSIONS

This program holds great promise to provide an index of year-class strength for walleye, white perch, and yellow perch, and to index adult populations of spottail shiner, trout perch, gizzard shad, alewife, johnny darter, and pumpkinseed. However, further exploration of habitat is required to find index sites for other species such as smallmouth bass. A good habitat map to show substrate and aquatic vegetation would be useful for this purpose.

ACKNOWLEDGEMENTS

Thanks to Bill Dentry, Dave Jeffrey, Mark Kimmet, Alastair Mathers, Ted Schaner, and Chuck Wood, for field assistance, and to Steve Nepszy for the loan of outboard trawls from Lake Erie Research Station.

REFERENCES

BOWLBY, J. N. 1988. Lake Ontario exploratory outboard trawling, field and data protocol manual, 1988. Ontario Ministry of Natural Resources. Lake Ontario Fisheries Unit. Picton. LOA 87-6.

BOWLBY, J. N. 1989. Lake Ontario exploratory outboard trawling, data summary and analysis, 1988. Ontario Ministry of Natural Resources. Lake Ontario Fisheries Unit. Picton. *In prep.*

JOYNER, S. P. 1985. SAS/STAT Guide for personal computers, version 6 edition. SAS Institute Inc. Cary, NC. 378 pp.

SOKAL, R. R., AND F. J. Rohlf. 1981. Biometry. W. H. Freeman and Company, San Fransico. 859 pp.

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MIDWATER TRAWLING FOR SMELT AND ALEWIFE IN THE WESTERN BASIN OF LAKE ONTARIO

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ABSTRACT

To examine the possibility of extending current bottom trawling program for rainbow smelt into areas of rough bottom unsuitable for bottom trawling, we compared day bottom catches with night midwater catches on 11 smooth bottom stations between Niagara and Toronto. Bottom and midwater trawls made at the same locations yielded different sizes of smelt, and the catches were poorly correlated. Echosounder data suggest, however, that the differences may be due to smelt behavior rather than inadequate performance by either gear. Alewife catches from bottom and midwater trawls were well correlated.

RECOMMENDATION

Do not continue this program in 1989. The extension of the early summer bottom trawling assessment of smelt into midwater is not likely, since a program for alewife and smelt is already being developed for the thermally stable midsummer season.

INTRODUCTION

Smelt stocks have been surveyed in a cooperative bottom trawling program by the U.S. Fish and Wildlife service (USFWS) and the New York Department of Environmental Conservation (NYDEC) since 1978 (O'Gorman and Schneider 1985). In 1981 the program was extended into Canadian waters, with sampling occurring on transects at Niagara Hamilton, and Toronto/Oakville, and the catches on the two sides of the border proved to be highly correlated (Stewart and Oliver 1989). Rough bottom east of Toronto precluded further expansion of the program.

The present study was conducted to assess the possibility of using midwater trawling in the areas of rough bottom. We compared the catches in the midwater and bottom trawls on the three transects that are currently sampled with bottom trawls, and sampled two additional transects east of Toronto using only midwater trawl.

METHODS

MIDWATER TRAWLING

Twenty one midwater trawls were completed on five transects from June 11 to 15, 1988. Three of the transects coincided with the ones used for bottom trawling, and two more were chosen at Bond Head and Lucas Point (Figure 1). At each transect we performed several trawls, usually at bottom depths of 20, 40, 60, 80 and 100 metres. All midwater trawls were done at night, when it was reasoned that smelt would be more vulnerable to the midwater gear as they disperse throughout the water column.

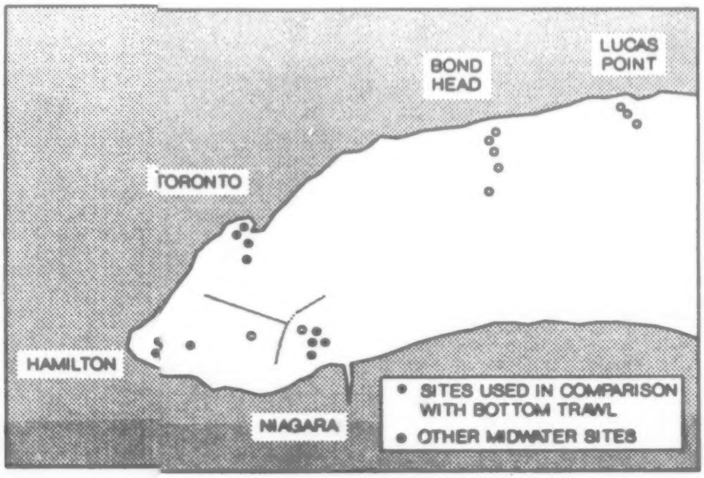


FIGURE 1. Midwater trawling locations. Dotted lines separate the three transects at Niagara, Hamilton and Toronto.

A midwater frame trawl was used. The bag was 11.8 m long, and had a square cross section, tapering from 4.2 m sides at the mouth to approx. 0.6 m at the end. The cod end was made of 1/2 inch mesh. The mouth of the bag was attached at top and bottom to 3.17 m horizontal bars maintaining spread. Vertical opening of approx 2.5 m was insured through floats attached to the upper bar and weights to the lower. The net was towed by a single cable, with bridles running to the four corners of the mouth.

We used stepped integrated trawls to sample throughout the water column, paying out 40 m of cable every 5 minutes (3 minutes in the deepest trawls), until the net was close to the bottom. The depth at the net was calculated from the angle and length of the towing cable. The first step was at 20 m of cable, corresponding roughly to a depth of 5 metres.

Fish in the catch were separated by species, counted, weighed in aggregate. all fish were also length tallied to the nearest centimetre.

BOTTOM TRAWLING

Bottom trawling was done by by R/V KAHO (USFWS) from June 3 to 6, 1988, with a 12 metre Yankee trawl, using to 10 minute tows (O'Gorman and Schneider, 1985). Sampling procedures were similar to those employed in midwater trawling, but total rather than fork lengths were measured, in accordance with USFWS sampling protocol. They were converted to fork lengths using linear regression.

ESTIMATES

Smelt from both types of trawl were divided into three size categories with boundaries at 85 and 115 mm fork length. The data were treated in terms of these categories because a preliminary inspection indicated differences in size composition in catches from bottom and midwater trawls (Figure 2). Catch per unit effort (CUE) for each size category, and for the total catch, were calculated as the number of fish caught per minute of trawling. For midwater trawls we also calculated depth-corrected CUE's, multiplying CUE by the station depth in meters. The reasoning for the latter statistic was based on the assumption that the smelt stay close to the bottom during the day, and disperse throughout the water column at night. The night midwater trawl would therefore sample lower densities of fish than the day bottom trawl, the dilution being proportional to the height of the water column. Alewife statistics were calculated similarly, but without division into size classes.

ECHOSOUNDING

Paper recordings from a Furuno FE400 echosounder were made during midwater trawls. The signal densities were visually categorized into three classes: (1) sparse, (2) medium, and (3) dense (examples in Appendix A). The upper 30 feet (9.1 m) of the water column were categorized separately and independently of the deeper water. This depth corresponds to upper to mid thermocline at the time of the survey.

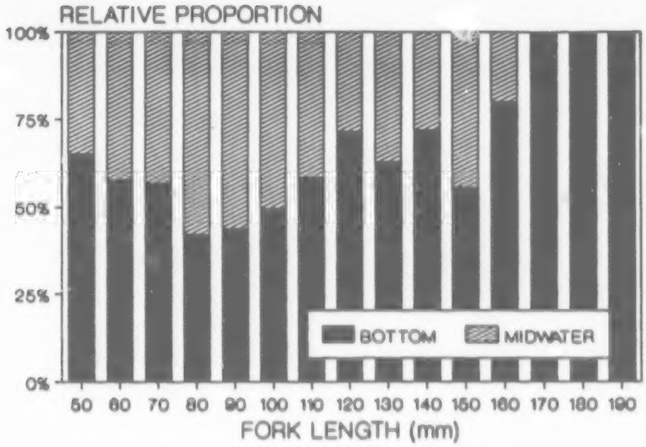


FIGURE 2. Comparison of bottom and midwater catches by size. The relative proportions of total numbers of fish caught in the two types of gear are shown. The midwater trawl did not catch any of the largest smelt caught by the bottom trawl.

RESULTS

SMELT

The bottom and midwater trawls have different efficiencies for the three size categories of fish (Figure 3). The pattern is not consistent, but in most cases the midwater trawl catches fewer large fish. The same pattern is also seen in the overall catch from the cruise (Figure 2).

Bottom and midwater CUE's are not significantly correlated either for individual size categories or for the total catch (Table 1, Spearman rank correlation). The correlations deteriorate further when the depth-corrected CUE's are correlated with the bottom trawls.

The echosounding data show good correlations with smelt catches from both types of trawl. The echogram densities from the upper layer correlate significantly with pooled (all sizes) midwater CUE, and also with the bottom CUE (pooled sizes as well as individual size categories). The correlations with echograms from water below 30 ft are weaker.

TABLE 1. Spearman rank correlation coefficients between various measures of catch per unit effort from bottom and midwater trawl and echograms. Sample size is indicated below each coefficient. Only those comparisons that can logically be made are shown. Significance: *p<0.05, **p<0.01. Raw data is listed in Appendix B.

	BOTTOM SMELT <85mm	BOTTOM SMELT 85-115mm	BOTTOM SMELT >115mm	BOTTOM SMELT All sizes	BOTTOM ALEW. All sizes	ECHOSOUNDING	
						Upper 30m	Below 30m
MIDWATER SMELT <85mm	0.39636 11					0.40248 * 17	0.57795 * 17
MIDWATER SMELT 85-115mm		0.35080 11				0.38826 17	0.42525 17
MIDWATER SMELT >115mm			0.53303 11			0.21044 17	0.39614 17
MIDWATER SMELT All sizes				0.52727 11		0.61306 ** 17	0.57424 * 17
MIDWATER ALEWIFE All sizes					0.78182 ** 11	0.68219 ** 17	0.37600 17
MIDWATER SMELT+ALEWIFE All sizes						0.59060 * 17	0.51073 * 17
MIDWATER SMELT DEPTH-CORRECTED <85mm	0.41818 11						
MIDWATER SMELT DEPTH-CORRECTED 85-115mm		0.10909 11					
MIDWATER SMELT DEPTH-CORRECTED >115mm			0.26364 11				
MIDWATER SMELT DEPTH-CORRECTED All sizes				0.26364 11			
MIDWATER ALEWIFE DEPTH-CORRECTED All sizes					0.85455 ** 11		
BOTTOM SMELT <85mm						0.84515 ** 8	0.54772 8
BOTTOM SMELT 85-115mm						0.84515 ** 8	0.63901 8
BOTTOM SMELT >115mm						0.73247 * 8	0.58685 8
BOTTOM SMELT All sizes						0.84515 ** 8	0.63901 8
BOTTOM ALEWIFE All sizes						0.84515 ** 8	0.31298 8

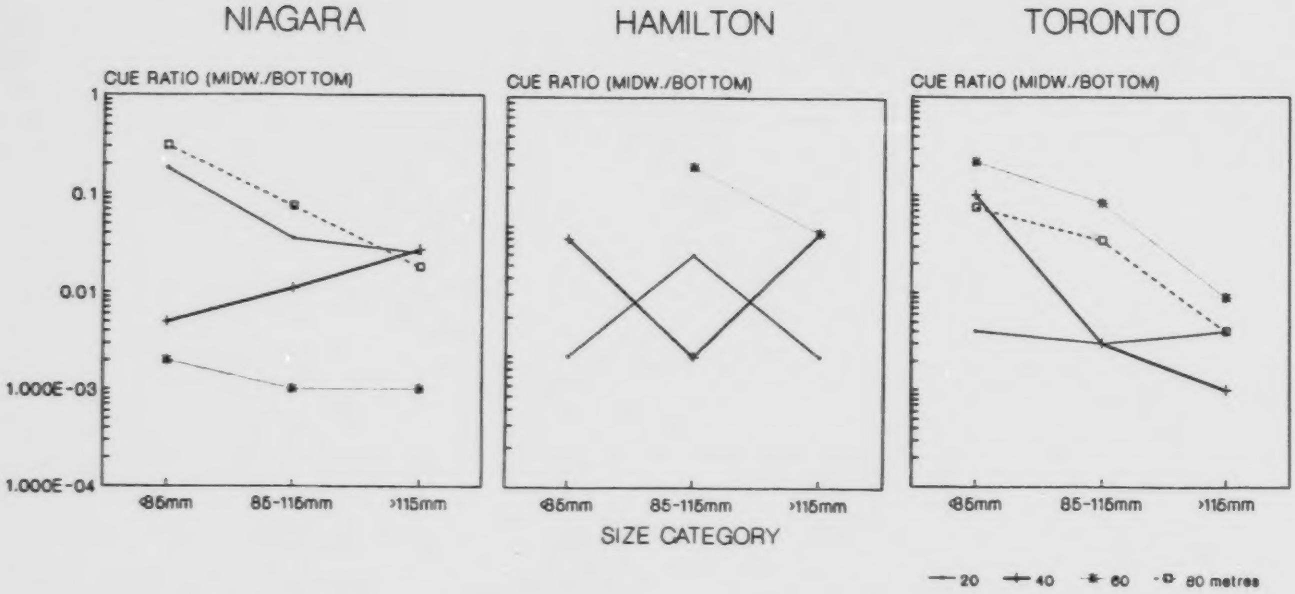


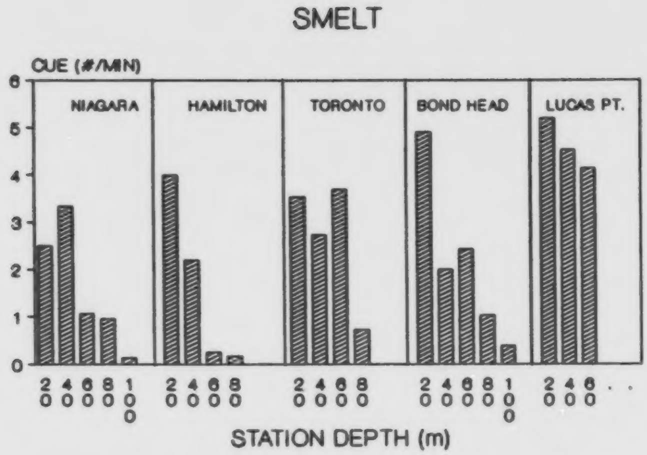
FIGURE 3. Ratios of midwater to bottom CUE's for the three size categories of smelt. The elevation of the lines has no significance, but the slopes indicate changes of efficiency of one gear relative to the other. Lines falling off to the right indicate decreased efficiency for large fish in the midwater trawl relative to the bottom trawl.

ALEWIFE

The bottom catches of alewife were significantly correlated with the midwater catches (with and without depth correction). The alewife catches from both gears were also significantly correlated with the echogram densities from the upper 30 feet.

MIDWATER CATCHES OVER SMOOTH BOTTOM

The highest catches of alewife and smelt at all fished depths were obtained at Lucas Point (Figure 4). At Bond Head the catches of both species were similar to those found at the three smooth bottom stations. We cannot do a meaningful statistical analysis of the differences in alewife and smelt abundances over the two bottom types because of the small sample size.



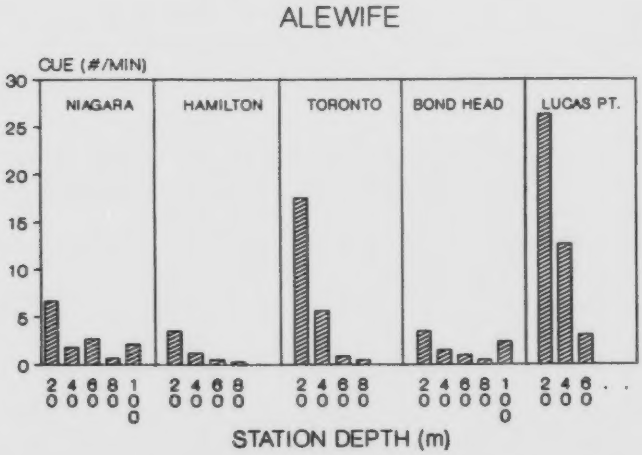


FIGURE 4. Midwater catch per unit effort for smelt and alewife from all stations.

DISCUSSION

The midwater trawls caught very small numbers of smelt and alewife. The tows were stepped, meaning that every 3 to 5 minutes we released more cable to allow the net to sink to the next depth. With time needed at each step for the net to adjust itself and to start properly fishing again, the effective tow duration may have been too short. It also appears that the fish were not uniformly distributed throughout the water column, and therefore tows stratified by layer would have been more appropriate than integrated tows spanning from surface to bottom.

The differences in size composition of smelt caught in the two types of gear may be due to size-dependent differences in gear selectivities. The midwater frame trawl has a smaller mouth, possibly allowing larger smelt to avoid capture. The two gears could also be sampling two different components of the population, if the movement off bottom depends on fish size.

There is no simple relationship between smelt catches from the two gears, though the matrix of correlations between CUE's and echosounder readings shows interesting patterns. There are strong correlations between daytime bottom catches and nighttime echograms from the upper layer but not from the lower layer. The correlations between day bottom and night midwater catches are not significant but they further decrease when the midwater CUE is corrected for station depth. These observations suggest that, contrary to our assumption, the smelt do not distribute themselves evenly throughout the water column at night. The strong correlations found between the echograms from the upper layer, and both bottom and midwater catches would further suggest that a significant portion of smelt move from the bottom to the surface at night, but we have no direct evidence to support this.

Further work would be required to relate the current bottom smelt program to a similar midwater program. However, the future of smelt assessment on the Canadian side of Lake Ontario is uncertain, since we are developing a prey (alewife and smelt) assessment program within the framework of COLA (Schaner 1989). That program will also use a midwater trawl but will be done later in the summer, when thermal conditions in the water column are more stable and predictable. Hydroacoustic assessment is not yet ready for implementation, but it too holds a future promise. For the time being, we therefore do not recommend that the current exploratory study be continued. Once the prey assessment program is developed, however, it will still have to be reconciled with the current bottom trawling program, possibly through a period of overlap.

Alewife were not a target species in our study. Nevertheless, the correlations between the two fishing gears and the echograms are noteworthy. Alewife assessment is currently done in the American waters of Lake Ontario through a bottom trawling program carried out earlier in the year, and midwater assessment during midsummer is being developed under COLA.

ACKNOWLEDGMENTS

We thank the U.S Fish and Wildlife Service in Oswego, N.Y. for sharing their data for this study, and for their cooperation in smelt assessment in the past.

REFERENCES

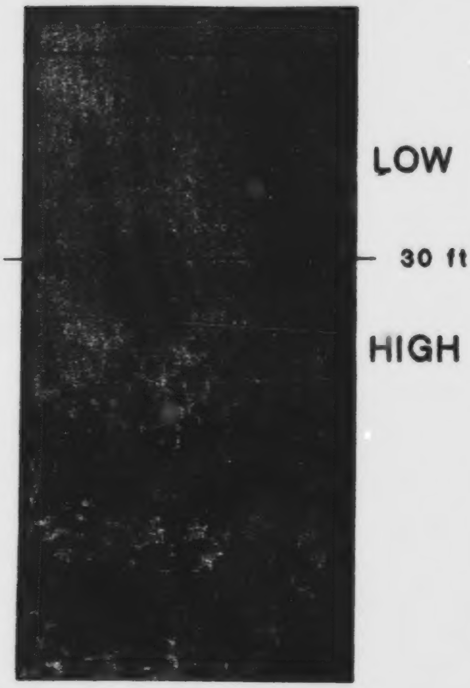
O'GORMAN, R., R.A. BERGSTEDT, and T.H. ECKERT. 1987. Prey fish dynamics and salmonine predator growth in Lake Ontario, 1978-84. Can.J.Fish.Aquat.Sci. 44(Suppl. 2):390-403.

SCHANER, T. 1989. Community Oriented Lake Assessment; the field program. *In* Lake Ontario Fisheries Assessment Unit 1988 Annual Report. LOA 89.1, Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit, Picton, Ontario.

STEWART, T.J., and J.D. OLIVER. 1989. Smelt abundance and growth in western Lake Ontario. *In* Lake Ontario Fisheries Unit 1988 Annual Report. LOA 89.1, Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit, Picton, Ontario.

APPENDIX A

EXAMPLES OF ECHOGRAMS AND THEIR RATINGS.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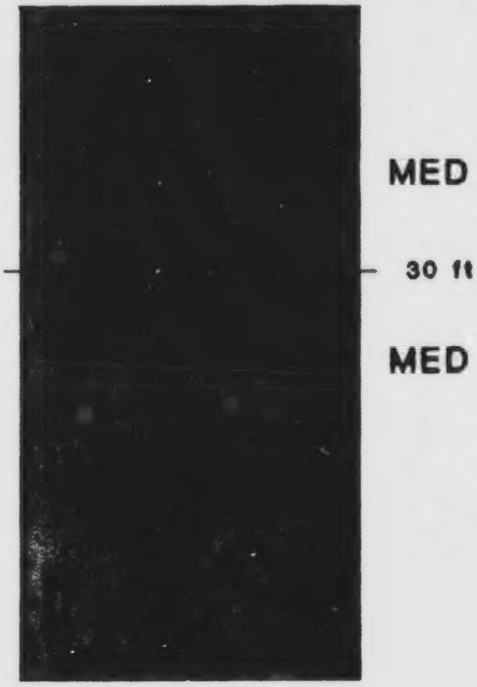
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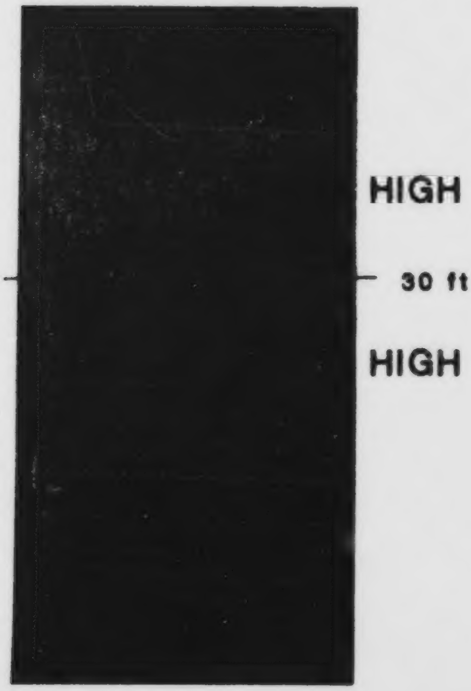
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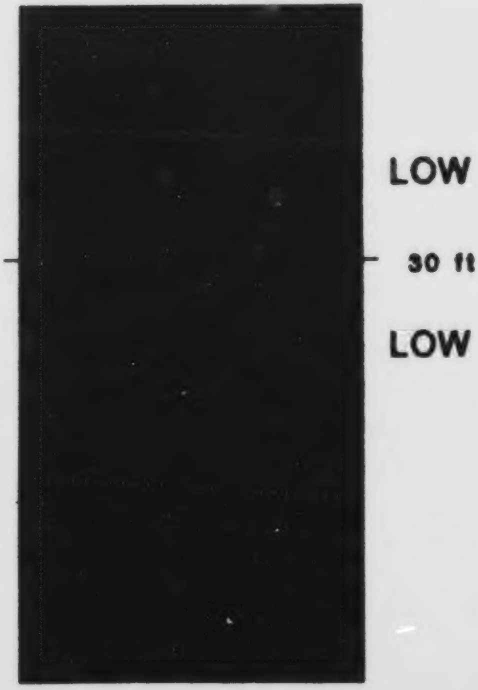
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APPENDIX B

TABLE OF BOTTOM AND MIDWATER CUE'S AND CORRESPONDING ECHOGRAM RATINGS.

SAMPLE ID				BOTTOM TRAWL CUE (#/MIN) *					MIDWATER TRAWL CUE (#/MIN)					DEPTH-CORRECTED MIDWATER TRAWL CUE (#/MIN*DEPTH)					ECHOSOUNDING	
				SMELT					SMELT					SMELT						
MIDW.	BOTTOM	AREA	BOTTOM DEPTH (m)	<85	85-115	>115	All	ALEW. All	<85	85-115	>115	All	ALEW. All	<85	85-115	>115	All	ALEW. All	Upper 30m	Below 30m
6	103,104	N	20	15.64	53.77	12.02	82.06	375.70	0.30	1.90	0.30	2.50	6.69	5.99	37.92	5.99	49.90	133.73	2	2
7	106	N	40	30.86	192.85	40.50	264.20	792.70	0.15	2.12	1.06	3.33	1.19	6.06	84.85	42.42	133.33	72.73		
8	108,109	N	60	58.06	680.21	355.05	1094.31	388.87	0.10	0.60	0.37	1.07	2.63	6.00	36.00	22.00	64.00	158.00		
9	110	N	80	0.70	7.20	11.61	19.50	61.30	0.21	0.54	0.21	0.96	0.67	16.67	43.33	16.67	76.67	53.33		
10		N	100						0.00	0.13	0.00	0.13	2.13	0.00	13.33	0.00	13.33	213.33		
12		H	80						0.03	0.07	0.07	0.17	0.30	2.67	5.33	5.33	13.33	24.00	1	1
13	113,114	H	60	0.22	5.20	11.57	17.39	34.20	0.00	0.15	0.10	0.25	0.56	0.00	9.09	6.06	15.15	33.33	1	1
14	115,116	H	40	17.18	141.22	61.85	233.91	182.38	0.13	0.15	0.53	2.20	1.20	5.33	61.33	21.33	88.00	48.00	2	3
15	119	H	20	180.42	457.99	69.39	707.80	711.50	0.20	2.69	0.10	3.99	3.49	23.95	53.89	2.00	79.84	69.86	2	2
17	123	T	80	1.75	16.59	6.77	25.1	42.80	0.13	0.57	0.03	0.73	0.47	10.67	45.33	2.67	58.67	37.33	1	2
18	122	T	60	3.25	32.81	27.89	63.98	23.00	0.71	2.73	0.25	3.69	0.81	42.42	163.64	15.15	221.21	48.49	1	3
19	128,129	T	40	58.70	665.14	222.32	961.81	1636.83	0.60	1.80	0.33	2.73	5.60	24.00	72.00	13.33	109.33	224.00	2	3
20	125	T	20	554.28	466.30	52.79	1073.37	4746.25	2.06	1.28	0.20	3.53	17.55	41.18	25.49	3.92	70.59	350.98	2	3
21		B	100						0.00	0.24	0.14	0.38	2.33	0.00	23.81	14.29	38.10	233.33	3	1
22		B	80						0.03	0.77	0.23	1.03	0.47	2.67	61.33	18.67	82.67	37.33	2	2
23		B	60						0.10	2.32	0.00	2.42	0.96	6.06	139.39	0.00	145.46	57.58	2	3
24		B	40						0.53	1.40	0.07	2.00	1.53	21.33	56.00	2.67	80.00	61.33	2	2
25		B	20						2.45	2.35	0.10	4.90	3.53	49.02	47.06	1.96	98.04	70.59	3	2
26		B	20						4.21	0.88	0.10	5.20	26.27	84.31	17.65	1.96	103.92	525.49	3	3
27		L	40						1.60	2.73	0.20	4.53	12.63	64.00	109.33	8.00	181.33	505.31	3	2
28		L	60						1.01	2.83	0.30	4.14	3.08	60.61	169.70	18.18	248.49	184.85	3	3

AREAS: N - Niagara, H - Hamilton, T - Toronto, B - Bond Head, L - Lucas Point

* Geometric mean of CUE from two stations used where two bottom stations are compared to one midwater station.

Great Lakes Fishery Commission
Lake Ontario Committee Meeting
March 21-22, 1989
Buffalo, New York

COMMUNITY ORIENTED LAKE ASSESSMENT

THE FIELD PROGRAM

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ABSTRACT

The 1988 field program was carried out south of Point Traverse in depths ranging from 35 to 110 metres. Bottom and midwater trawls, and bottom and midwater gillnets were used in an exploratory fashion to gain experience with the gear, and to determine the suitability of the gear in various situations. The spatial and temporal distributions of the fish were also examined in terms of bottom depth, position in the water column, and time of day or night. Our best data concerns the distribution of alewife, smelt, and to a lesser degree sculpin and lake trout. Temporal and/or spatial patterns of distribution were found in all cases. Other salmonines were not caught in sufficient numbers to allow any conclusions, and methods and locations of capture will have to be developed to allow assessment.

RECOMMENDATIONS

These recommendations do not represent the scope of the COLA program, and they are only based on the results obtained in the 1988. Points 1, 2 and 3 are will be addressed in the 1989 field season.

1 Conduct a midwater trawling frame survey in the Eastern Basin to follow up on the results obtained last year on alewife and smelt. This survey will collect the statistical parameters necessary to desigh an assessment program.

2 Adress the remaining issues in midwater trawling:
  1) Choice of gear (diamond vs frame trawl)
  2) Contamination of samples during lowering and lifting of net.
  3) Effects of boat on catches made near the surface.
  4) Advantages of night trawling.

3 Assess the possibility of catching sufficient and representative numbers of salmon and trout, using currently available fishing methods (trawl and gillnet) fished in an optimal manner. Develop alternatives in case of failure.

4 Initiate a sculpin assessment program. Evaluate, and possibly adopt the program currently used in L.Ontario by the U.S. agencies, or develop a new one.

INTRODUCTION

The Community Oriented Lake Assessment Program (COLA) had its first field season in 1988. The objectives were partly practical: to test a newly outfitted boat, and to develop expertise in midwater trawling and midwater gillnetting. The investigative goals were to describe the distribution of fish in the offshore zone in depths greater than 30 metres, and to assess the suitability of various gears and fishing methods for collecting these fish. We chose an approach based on fishing sites, where each of randomly selected sites would be fished using all methods during the day and at night. The methods were bottom and midwater trawls and bottom and midwater gillnets.

Problems with newly installed hydraulic equipment caused delays in the sampling schedule, and therefore midway through the season the strategy was changed to collect data from 5 sites of varying bottom depth. The results presented in this report do not have the strength envisioned in the original plan, but they answer questions concerning the distribution of the fish and suitability of the methods.

METHODS

SAMPLING SITES

All sites 1988 were on a line south off Point Traverse, at 35, 50, 70, 90 and 110 m bottom depths. At each site we set a bottom and a midwater gillnet, and performed a number of bottom and midwater trawls. Figure 1 indicates bottom depth, and time of the day, and it also shows the vertical extent of the midwater trawls.

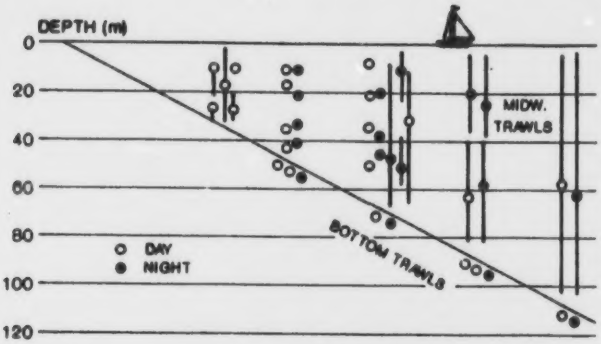

FIGURE 1. Distribution of trawls in the 1988 program. Vertical lines represent the range of depths in stepped oblique tows.

TRAWLING

Thirty midwater trawls were completed using the diamond trawl (TW52[1], 14.6 m headrope, footrope and down-lines) with 1.93 x 0.81 m Suberkrup doors. Two nets of similar dimensions were used in the course of the summer. Several trawling techniques were tried: single depth trawls as well as stepped trawls spanning either the entire water column or a portion thereof. In the single layer trawls we towed for 20 minutes in the target depth. In the stepped trawls we spent 3 or 4 minutes at each depth including time to bring the trawl to the depth, but not the initial time to lower the gear to the first depth. The cable was paid out in 10 m increments in the stepped trawls, roughtly corresponding to 3 m depth increments. The fishing depths were estimated from the length of the towing cables and their angle of entry. All trawls were done at 1100 rpm, corresponding to approximately 2.5 knots (the speed at given rpm varied slightly, probably due to weight distribution on the boat, and consequent problems with propeller cavitation; at 1100 rpm we measured speeds between 2,5 and 2.7 knots).

The use of several different midwater trawling methods required that some overall classification be used in order to compare the catches from all trawls. The following designations will be found in the discussion of the results:

1 *Epilimnion trawls* -either stepped or single layer, but restricted to the epilimnion.
2 *Upper layer trawls* - stepped trawls spanning the epilimnion and the upper portion of the metalimnion.

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[1] The gear designations refer to Lake Ontario Fisheries Unit's gear catalog, which also contains more detailed description of the gear.

3 *Metalimnion trawls* - stepped or single layer, restricted to metalimnion.
4 *Lower layer trawls* - stepped trawls spanning the hypolimnion and the lower metalimnion.
5 *Hypolimnion trawls* - stepped or single layer, restricted to the hypolimnion.

We also made stepped oblique trawls that spanned the entire water column, but they were not used in the analysis.

Ten bottom trawls were completed using the TW64 3/4 Yankee trawl (TW64[1], 16.4 m headrope with 2.13 x 0.97 m doors. It was towed with scope ratios ranging from 2.5:1 to 3.0:1 at 1100 rpm (corresponding to approximately 2.5 knots). All trawls were kept constant at 20 min bottom time.

MEASUREMENTS OF FISHING DEPTH USING SCANMAR NET TRANSDUCER

The SCANMAR net transducer measures the depth at the fishing gear, and transmits the information acoustically to an on-board receiver. We had the equipment on loan from NYDEC, Cape Vincent, on two occasions in order to monitor the position of the midwater trawl. The relationship between the depths measured by SCANMAR and the depths calculated from the cable angles and lengths were different on the two occasions. This was probably due to differences in the amount of weight attached to the trawl doors, and differences in the gauge of the cable used for towing. The error in the calculated depth for the configuration used most of the summer was approximately 14% (e.g. a calculated depth of 100 m would correspond to an actual depth of 86 m).

The SCANMAR equipment, with additional transducers to measure the trawl opening, was also used to assess the operating characteristics of the bottom trawl and the midwater frame trawl. The results can be found in Christensen (1989) and Schaner (1989).

GILLNETTING

All gillnets were standard Glenora Fisheries Station lake gillnets (GL02[1]) consisting of panels of multifilament mesh from 1.5" to 6" in half inch increments. The two smallest-mesh panels were 22.8 m (25 yds) long, and the remainder measured 45.7 m (50 yds). Sets were made both on the bottom and in the water column. The midwater sets were suspended from surface buoys by 25 m lines attached to the float line at 25 m intervals. The nets were anchored at both ends.

In the discussion of the gillnet results, I make comparisons with the Rocky Point transect, which is just inshore of our stations. It was fished with bottom gillnets in July and August as part of the warmwater survey. Full description of the program can be found in Mathers (1989) in this Annual Report. The main difference in gear was that the 5.5" and 6" meshes were not used in the warmwater program.

CATCH SAMPLING

Fish were counted and weighed by species, and a representative length tally of each species was compiled. The details of obtaining the weights and tallies differed slightly between the gillnet and trawl samples. In the gillnets we counted, weighed and tallied all fish caught, keeping separate records for each panel and species. In the trawls we counted, weighed and length tallied all large fish (i.e. salmonids) to the nearest centimetre. The bulk of the remainder typically consisted of alewife, smelt and sometimes sculpins. If the total weight of this mixture was under 3 kg we separated the entire catch by species and processed it as above. Otherwise we weighed the mix, and took an approximately 2 kg random subsample, which we separated by species and processed as above. The numbers were then prorated by weight to calculate the total numbers caught. All fish in the subsample were length tallied.

ESTIMATES

For each trawl we recorded the Loran-C coordinates for the beginning and the end of the trawl, from which the trawling distance was calculated. The catch per unit effort (CUE) for individual trawls were calculated by prorating the catches to 1000 m. Mean CUE's were calculated as geometric means.

In gillnets, the catch from each of the eight panels was prorated to 12.5 m of net, and the catches from all panels comprising a set were added. The CUE from the individual sets thus corresponds to the catch of an eight-panel net with equal panel sizes, measuring 100 m in total. Mean CUE's were, again, calculated as geometric means. The CUE's from the warmwater program at Rocky Point, used here for comparison, were converted to the same units as our estimates, but they are not fully comparable because the two programs used different combinations of mesh sizes.

RESULTS

Alewife and smelt were common to all gears (Table 1). We also caught large quantities of sculpin in the bottom trawls but over half the catch came from a single trawl. We had large catches of lake trout in gillnets, especially those set on the bottom, while only 3 lake trout were caught in the trawls. The midwater gillnets also caught 3 chinook salmon.

TABLE 1. Summary of catches (numbers of fish) in the various gears used in 1988.

Species	Gear Midwater trawl	 Bottom trawl	 Midwater gillnet	 Bottom gillnet
Alewife	7030	1586	36	307
Rainbow smelt	682	293	10	49
Sculpin spp.	3	936	-	1
Lake trout	3	-	65	233
Chinook salmon	1	-	3	-
Lake whitefish	-	-	1	-
Lake herring	-	-	-	1
3-sp.stickleback	5	-	-	-

ALEWIFE

Among the midwater trawls, the greatest catches of alewife were found in the upper layers of the water column during both day and night (Figure 2). The catches from the bottom trawls are not to be compared with the midwater catches because a different net was used. The comparison of the day and night bottom trawls, however, suggests that the alewife move off the bottom at night.

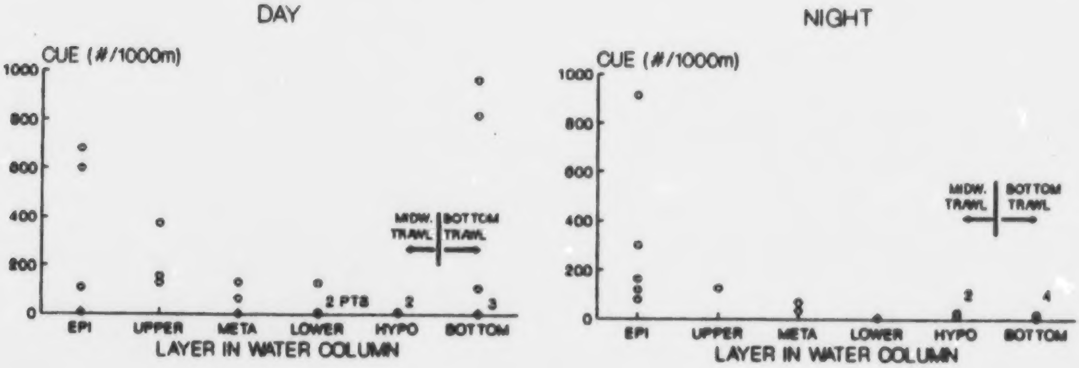


FIGURE 2. Trawl catches of alewife from various positions in the water column. Individual trawls are shown. The bottom trawl catches are also shown but they should not be compared to the midwater catches due to gear differences.

The distribution of trawl catches between shallow and deep stations does not reveal a pattern (Figure 3). However, the corresponding data from the midwater and bottom gillnets suggest that the alewife are more abundant at shallower stations, as shown in Figure 4. The figure also includes the catches from the Rocky Point transect (warmwater program), indicating that even at the most productive depth (50 m) the alewife abundance was lower than what could be found in the warm water of less than 30 m. Thus near bottom at least, the greatest numbers of alewife can be found in the shallow warm water, but their range extends into the deeper cold water (70 m).

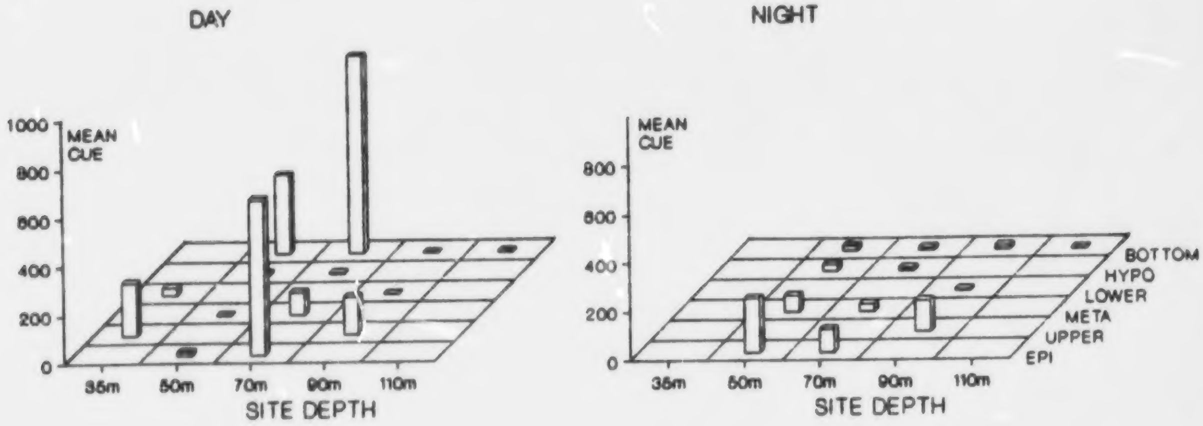


FIGURE 3. Distribution of trawl catches of alewife by bottom depth and position in the water column. Data from Figure 2 but mean CUE in each cell is shown.

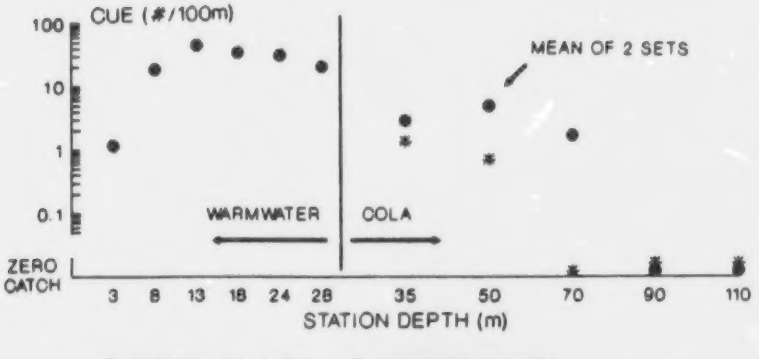


FIGURE 4. Catches of alewife in gillnets. All points but one represent single sets. Data from LOFU's warmwater gillnetting program (Rocky Point station) is also included for comparison; those data are the mean of 3 gillnet sets.

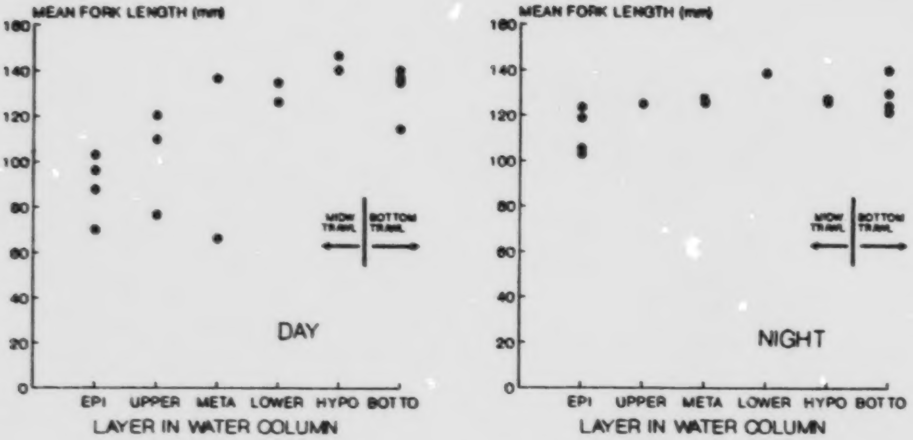


FIGURE 5. Mean sizes of trawl caught alewife from various positions in the water column. Each point represents one trawl.

The smallest alewife are found near the surface, and the mean size increases towards the bottom (Figure 5 and Appendix A). The differences are especially pronounced during the day. While doing the gear trials we even had some indication that the surface layer may contain juvenile alewife: in one surface trawl we caught several kilograms of 40-45 mm alewife, a size category that was normally found only in small numbers in the deeper trawls.

RAINBOW SMELT

The catches of smelt in the midwater trawl increase towards the bottom, both during the day and at night (Figure 6). The differences are greater during the day - no smelt were ever caught in the epilimnion or in the upper layer during the day, and similarly only one of three daytime metalimnion trawls had any smelt. There are also differences in smelt abundance with bottom depth (Figure 7) in that most smelt were caught at the shallower stations in both the midwater and the bottom trawls. The same pattern is shown in the gillnet data, both bottom and midwater (Figure 8). Comparison of bottom gillnet catches with those from the warmwater program indicates that the range of the smelt extends into water as shallow as 10-15 metres.

The data on size distribution do not indicate any strong size differences between the fish from the various layers of the water column (Figure 9 and Appendix B), except that smelt caught on the bottom during the day were consistently large.

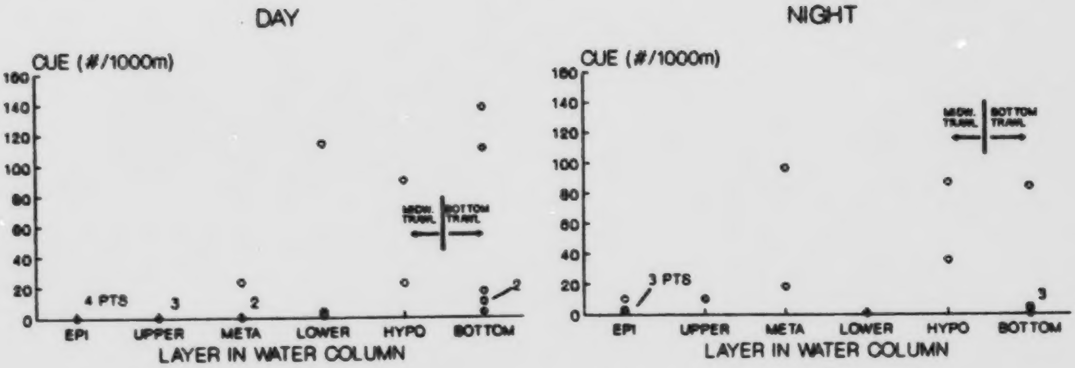


FIGURE 6. The trawl catches of smelt from various positions in the water column. Individual trawls are shown. The catches from the bottom trawls are also shown but they should not be compared to the midwater catches due to gear differences.

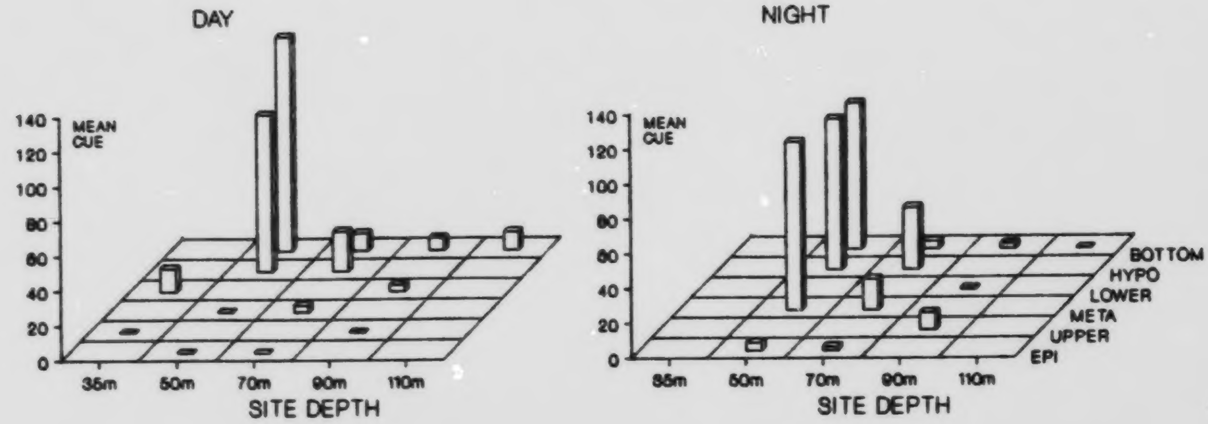


FIGURE 7. Distribution of trawl catches of smelt by bottom depth and position in the water column. Data from Figure 2 but mean CUE in each cell is shown.

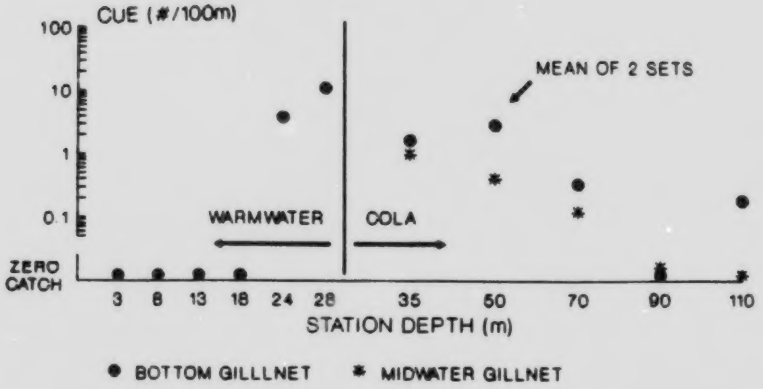


FIGURE 8. Catches of smelt in gillnets. All points but one represent single sets. Data from LOFU's warmwater gillnetting program (Rocky Point station) is also included for comparison; those data are the mean of 3 gillnet sets.

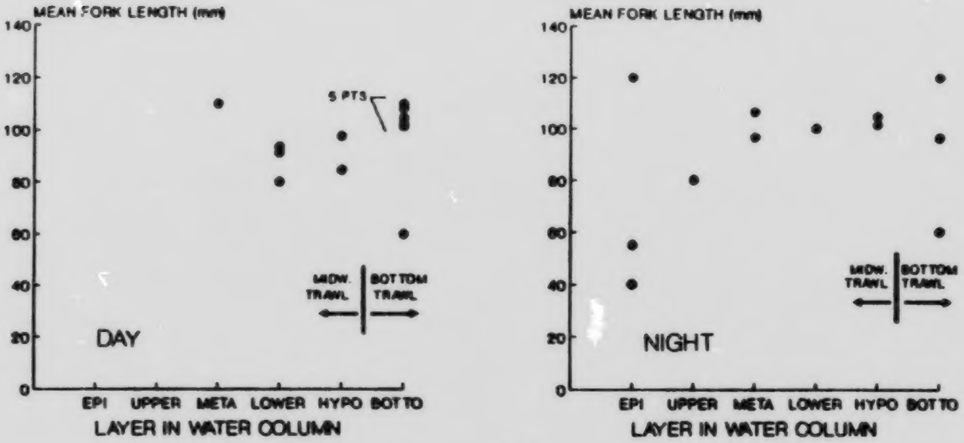


FIGURE 9. Mean sizes of trawl caught smelt from various positions in the water column. Each point represents one trawl.

SCULPINS

We caught mottled sculpins (Cottus bairdi Girard) and slimy sculpins (Cottus cognatus Richardson). We did not distinguish between the species in our sampling, because the identification is difficult and time consuming. The sculpins showed a strong trend in CUE with bottom depth - the catches decreased towards deeper water (Figure 10.A). There were no differences in the daytime and nighttime catches. The mean size of the sculpins increased towards deeper water (Figure 10.B).

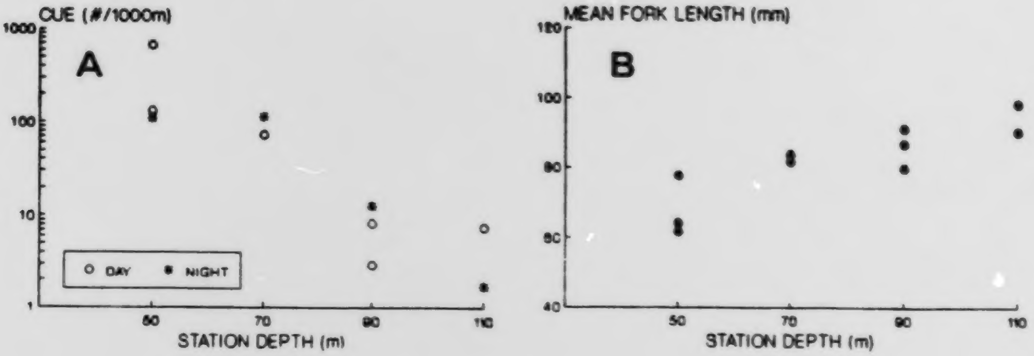


FIGURE 10. Sculpins in the bottom trawl. A. catch per unit effort
B. mean sizes.

LAKE TROUT

Only the gillnets produced substantial catches of lake trout. Both the midwater and especially the bottom gillnets were more productive on the shallower stations (Figure 11), but the catches from the warmwater program show a decrease when going further inshore. The data hint at differences in the size composition when comparing the catches of the bottom and midwater sets made at the same station (Fig. 12). At 50 m depth the midwater set caught very few small fish coompared to the bottom set. The opposite is true of the sets made at 35 m. (The other depths did not yield enough fish for comparison.) No conclusions should be reached from these sparse data, but the possibility of size segregations should be noted and addressed in the assessment of lake trout.

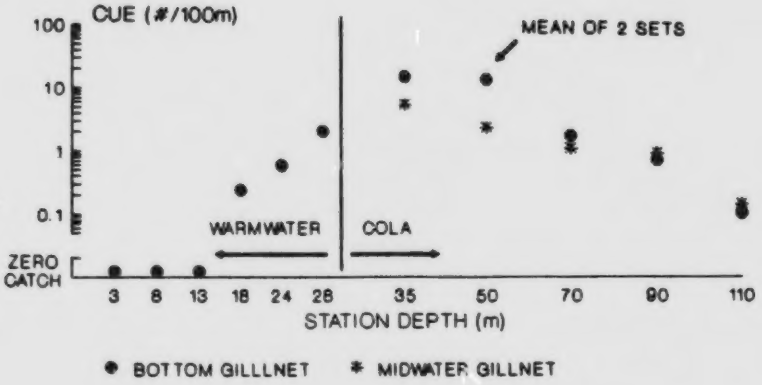


FIGURE 11. Catches of lake trout in gillnets. All points but one represent single sets. Data from LOFU's warmwater gillnetting program (Rocky Point station) is also included for comparison; those data are the mean of 3 gillnet sets.

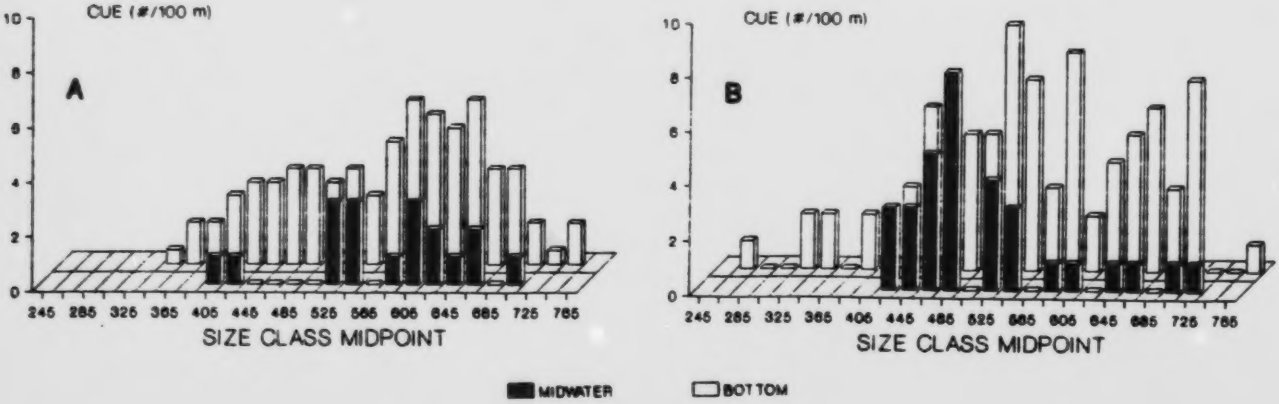


FIGURE 12. Size composition of lake trout at the two depths of greatest abundance: (A) - 50 metres, and (B) - 35 metres. The midwater sets in the foreground are contrasted with the bottom sets in the background.

DISCUSSION

We found differences in catches of the prey species along the bottom depth gradient, and along the depth in the water column. The differences are seen in the catch per unit effort, and in the case of alewife also in the size of the fish. There are day/night differences in the vertical distribution of the smelt, and similar but size-dependent differences in the distribution of alewife. At all times smelt and alewife can be caught by both the bottom and the midwater trawl. The gillnet catches of both species are low, though higher catches of alewife and smelt are seen in the shallow nearshore waters sampled by LOFU's warmwater program.

The implications for sampling these species are the following:

1. Trawling is the method of choice for assessment, since it yields higher catches, and it is easier and less time consuming. Both the midwater and the bottom trawls should ideally be used in order to sample all segments of the populations. Practical constraints (time and bottom types in L.Ontario) may limit the trawling to midwater, in which case the information on the fish found on the bottom is lost.
2. The trawls must be stratified by bottom depth and by vertical layers because differences in abundance and size composition have been detected. The bottom depth strata should extend into as shallow water as practical to cover the entire range of distribution.
3. The merits of day vs. night trawling should be considered. Against the obvious logistic advantages of daytime work, the night trawling offers a greater dispersal of the fish, therefore possibly lower catch variances, and less sensitivity to sloppiness in method. These differences should be quantified to justify the choice of sampling period.
4. Work done in the early summer of 1988 (Schaner and Stewart, 1989, in this Annual Report) indicates that the smaller frame trawl may be suitable if we are only concerned with alewife and smelt. This gear is easier and faster to use, and less expensive. It could also be developed for use immediately close to the bottom, mitigating the lack of true bottom trawls.

There remain technical problems associated mainly with midwater trawling. The most important problem was our inability to fish near the bottom. This was due to the fact that the hydraulic system on our boat was powered from the main engine, forcing the boat to slow down before beginning to haul in the trawl, and consequently letting the trawl drop to the bottom. The problem will be remedied by next season. Potential inaccuracy in calculating the fishing depth from the warp length and angle is also a problem, especially when we fish deep and close to the bottom. It is possible to construct empirical tables that show the fishing depth as a function of these two variables, however, it will be simpler to use a depth measuring net transducer in the future.

There are two effects that may bias the catches in midwater trawls:

1. The amounts of fish caught during lowering and raising of the trawls to the target depth are not known. This is potentially important when doing hypolimnetic trawls, which are expected to catch few fish, yet having to pull them through high fish den-

sities in the epilimnion. Our greatest concern in this respect would be with alewife from deep water, and indeed, the 1988 catches of alewife from the hypolimnion may partly be an artifact.

2 The effect of the boat and its prop wash on the midwater trawling catches from the near-surface layers is unknown. It may be exacerbated by the fact that these trawls use short lengths of towing cable, and therefore the catching occurs immediately behind the boat.

It is possible to ignore both effects, since we are developing an index program, and such biases can be absorbed without impairing the ability to detect year to year changes. They are, however, easy to quantify, and the knowledge would add to the value of data collected in the future.

The catches of salmonines in the midwater trawls were very small, and certainly insufficient for any kind of assessment using this method. There is reason to believe that optimizing the method in terms of trawling speed and time, the size of the net, and the sampled habitat, would increase the catches (C.Schneider, unpubl.). Similarly, the midwater gillnets, which in 1988 proved to be only efficient for lake trout, could be optimized in terms of setting depths and mesh size to yield higher catches. Both methods will be investigated in 1989 to determine their suitability in salmonine assessment. If our efforts next year are not successful, then gillnetting will continue to be useful in lake trout assessment, while a new method will have to be developed for the other pelagic salmonines.

Sculpins were only caught in bottom trawls. With the emphasis on midwater trawling for alewife and smelt, and some yet undetermined method for salmonines, the sculpins will likely be addressed in a separate bottom trawling program. The large areas of uneven bottom on the Canadian side of Lake Ontario will always be a complicating factor in their assessment, and we will either have to restrict ourselves to trawlable substrate or develop a method of capture suitable for all bottom types. A bottom trawling program currently exists in the New York waters of the lake, and development of a similar program in Ontario would be a good first step.

REFERENCES

CHRISTENSEN, C., 1988. Scanmar measurements on LOFU's bottom and midwater trawls. Lake Ontario Fisheries Assessment Unit, Internal Report LOA 88.09.

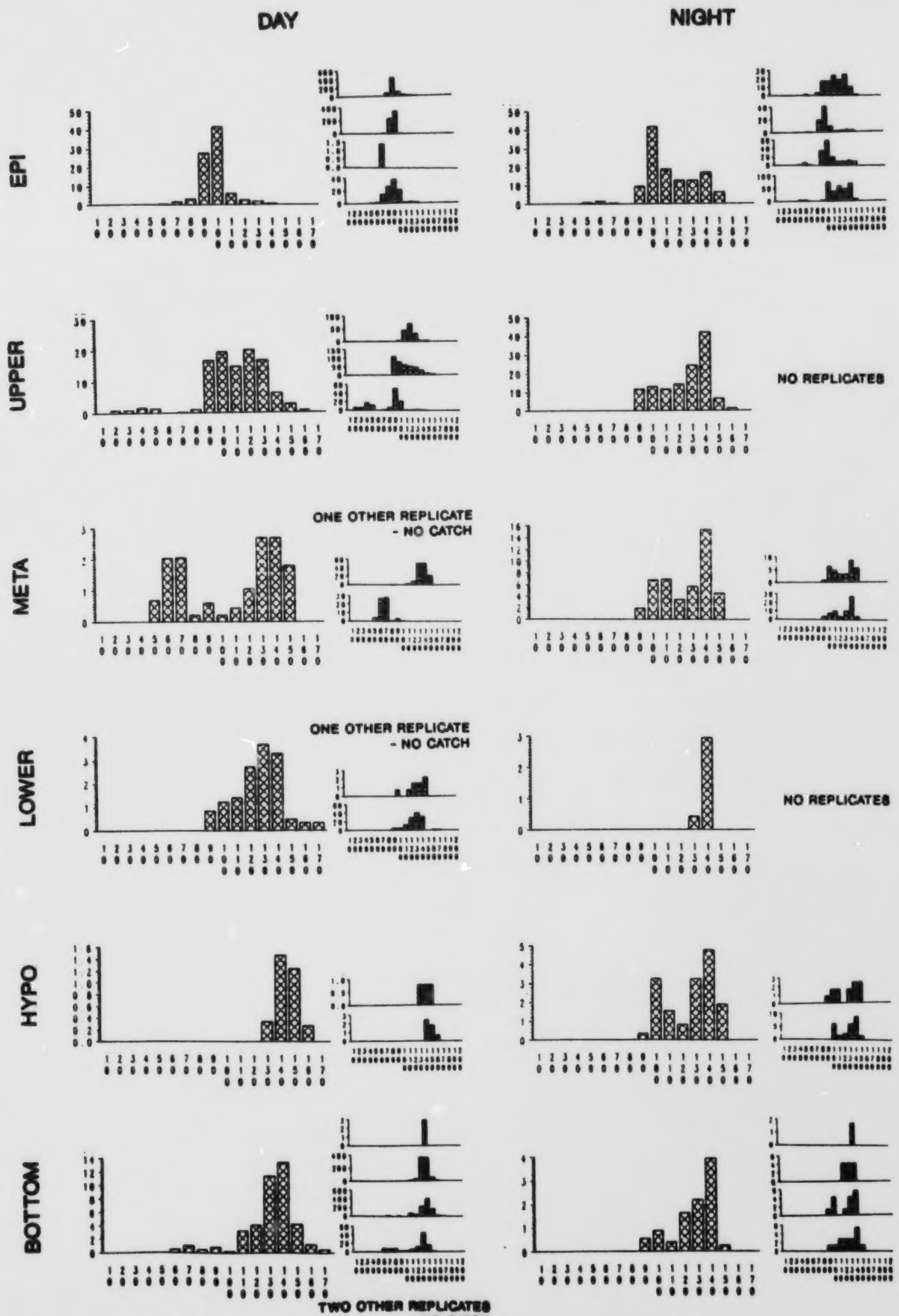
MATHERS, A., 1989. Index gillnetting project 1988. In Lake Ontario Fisheries Assessment Unit, 1988 Annual Report.

SCHANER, T., 1988. Measurements of trawl net characteristics under tow, using SCANMAR transducer system. Lake Ontario Fisheries Assessment Unit, Internal Report LOA 88.08.

APPENDICES

Comparison of fork length distributions from various position in the water column, and between day and night. Overall distribution for each stratum (large figures) is shown together with distributions from individual trawls (small figures). The scale on the ordinate varies between individual histograms.

Appendix A - Alewife
Appendix B - Rainbow smelt



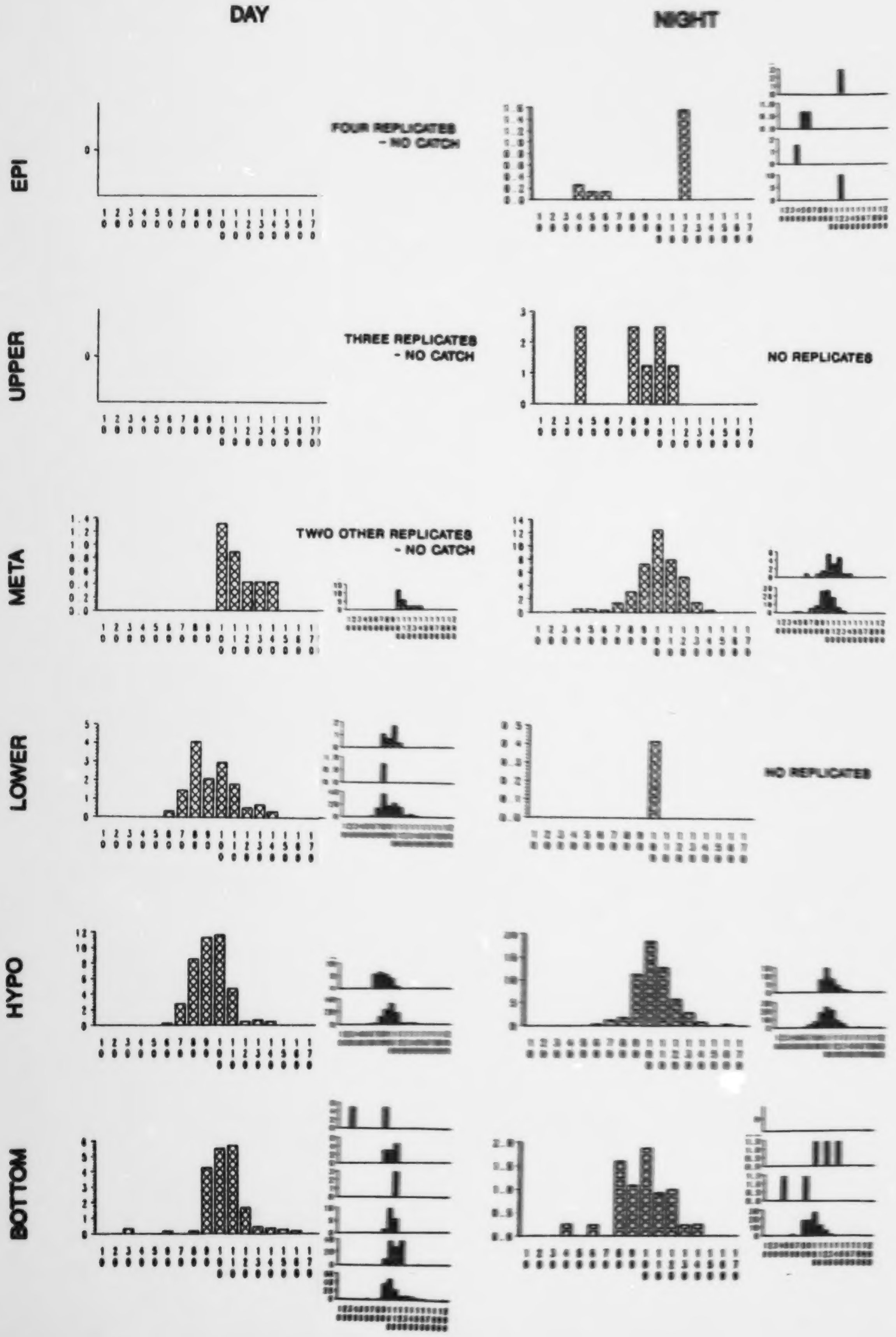
NO REPLICATES

ONE OTHER REPLICATE - NO CATCH

ONE OTHER REPLICATE - NO CATCH

NO REPLICATES

TWO OTHER REPLICATES - NO CATCH


DAY
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FOUR REPLICATES - NO CATCH
THREE REPLICATES - NO CATCH
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Great Lakes Fishery Commission
Lake Ontario Committee Meeting
March 21-22, 1989
Buffalo, New York

COMMUNITY ORIENTED LAKE ASSESSMENT

REPORT ON ACTIVITIES

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Community Oriented Lake Assessment (COLA) is a program to develop lake-wide sampling of the fish community in Lake Ontario. It was initiated by the Ontario Ministry of Natural Resources with participation from the New York Department of Environmental Conservation, and the U.S. Fish and Wildlife Service.

THE DIRECTION OF COLA

The Canadian managers have met in Kingston in August 1988 to evaluate the progress of the program, and to agree on future direction. The commitment to the cooperative Canada-US nature of COLA was confirmed, and the time frame and expectations for the study were clarified. The managers agreed to submit a detailed list of management information needs, to be integrated with the list compiled previously, based on biological factors. It was also agreed that the COLA steering committee would make the objectives more specific, and assign priorities. The management information needs have since been identified. They are similar and compatible with the list previously drafted as a framework for program planning.

The program's objectives were modified at the steering committee meeting in October. In summary, the long term objectives, in order of priority, are to establish trend through time indices of (1) individual fish stocks, and of (2) fish communities, and (3) to develop and refine predictive models of the major communities. The implementation objectives, guiding the program in the immediate future, are (1) develop sampling programs to index individual fish stocks, and (2) learn how to describe the fish community seasonally and spatially within the eastern Basin of Lake Ontario. The technical committee was charged to outline the projects for 1989-91 to meet these objectives.

FIELD ACTIVITIES

During the winter of 1987/88 R/V Steelcraft underwent modifications to the superstructure, and was refitted with hydraulics taken off R/V Cottus. The boat was used during spring lake trout stocking in the Kingston Basin, and afterwards it was dedicated to COLA and associated projects.

During June COLA participated in forage fish assessment in the western portion of the lake. Day catches of smelt and alewife in the bottom trawls (collected as part of an ongoing program by USFWS's R/V KAHO) were compared with night catches in midwater trawls. The comparison occurred on three transects between Niagara and Toronto. We then proceeded to midwater trawling between Oshawa and Brighton, an area where bottom trawling is not practical due to bottom conditions (see Schaner and Stewart, 1989).

In late June we measured the operating dimensions and towing depths of our trawls using SCANMAR transducers. We confirmed that our bottom trawl operates similarly to those used by NYDEC and USFWS, and we also established measurements for two midwater trawls (Schaner 1988, Christensen 1988). However, because of mechanical problems on the Steelcraft, the measurements had to be done using NYDEC's R/V Seth Green. This may not have affected the opening characteristics of the nets, but the towing depths differed due to the heavier towing cable used on the Seth Green. More appropriate measurements of the towing depths, using the Steelcraft, were made later in the summer.

The main field program was designed to describe the spatial and temporal (day/night) distribution of fish in an offshore area, and to test various available methods of capture. We used midwater and bottom trawls, and midwater and bottom gillnets. All gears were to be deployed on each of a number of sites, using 24-hr gillnet sets, and trawling both during the day and at night. Mechanical difficulties with the hydraulics forced us to reduce the number of sites to five. The sites were, however, spaced across the range of depths, and likely represent fish distribution in relation to bottom depth (see Schaner 1989).

The mechanical problems encountered throughout the summer stemmed mainly from faulty installation of the hydraulics. Most of these problems were gradually rectified by installing additional valves and new pressure hoses. The system was still deemed unsafe,however, and the fact that the hydraulics were powered by the main engine made it impossible to midwater trawl near the bottom. All problems are now being rectified through installation of new hydraulics independently powered by a diesel generator.

ACKNOWLEDGMENTS

I would like to thank all parties involved in the development of COLA for the initiative, the cooperation and the patience necessary to get the project off the ground. The field crew of Dale Dewey, Peter Klaassen, Mike Allen, Jim Boraski, Mike Brousseau, Scott Ferguson, and Tim Shannon worked long and hard hours to collect the data. The loan of SCANMAR headrope transducer from the New York Department of Environmental Conservation at Cape Vincent was greatly appreciated.

REFERENCES

CHRISTENSEN, C. 1988. Scanmar measurements on LOFU's bottom and midwater trawls. Internal Report LOA 88.09, Ontario Ministry of Natural Resources, Lake Ontario Fisheries Assessment Unit, Picton, Ontario.

SCHANER, T. 1988. Measurements of trawl net characteristics under tow, using SCANMAR transducer system. Internal Report LOA 88.08, Ontario Ministry of Natural Resources, Lake Ontario Fisheries Assessment Unit, Picton, Ontario.

SCHANER, T., and T.J. STEWART. 1989. Comparison of alewife and smelt bottom and midwater trawling in the western basin of Lake Ontario, 1988. *In* Lake Ontario Fisheries Assessment Unit 1988 Annual Report LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Assessment Unit, Picton, Ontario.

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WALLEYE POPULATIONS IN EASTERN LAKE ONTARIO AND THE BAY OF QUINTE, 1988

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ABSTRACT

One mark-recapture session was conducted from August 31 to November 16, 1988, with 515 trapnet nights of effort. The population estimate of 2-year-old and older walleye was 681,488 during fall 1988. As a result of increased fall effort, this was the first time that we have been able to make mark-recapture estimates of the number of 1-year-old walleye, and this was the first time that we have had any confidence in our estimates of 2-year-olds. Anglers had the greatest impact on 4-year-olds, harvesting close to 40% of them in the summer fishery. Anglers harvested much fewer walleye in the winter fishery and were non-selective of walleye older than 2 years. The 1988 year-class of walleye appears to be moderate in strength, based on catches of young-of-the-year (YOY) in Bay of Quinte research trawls. Since 1981, the catch of YOY walleye has been highly correlated with the population of 2-year-old walleye in eastern Lake Ontario.

RECOMMENDATIONS

1. Continue the mark-recapture program in 1989 with similar procedures as used in 1988 to improve our estimates of 1-year-old walleye.

2. Further sampling must be done to confirm the utility of the relationship between YOY and 2-year-old walleye for predictive purposes.

INTRODUCTION

This report is an annual update of the status of walleye (*Stizostedion vitreum*) in the Canadian part of Eastern Lake Ontario and the Bay of Quinte. It complements three other reports on walleye in this volume. First, Mathers (1989) describes the walleye harvest by anglers during 1988. Second, Bowlby et al. (1989) describe long-term changes in walleye populations, harvest, and life history characteristics. Finally, Bowlby and Mathers (1989) describe the walleye harvest management model used to evaluate potential management strategies.

MARK-RECAPTURE PROCEDURES

The mark-recapture program was altered in 1988 to reduce some of the bias related to sampling season and location. A single mark-recapture session was conducted from August 31 to November 16, 1988, with 515 trapnet nights of effort (495 nights of effort were directed primarily towards walleye). The spring session during spawning was discontinued because few prespawning walleye were captured, and because spawning populations were not mixed at this time. Also, we stratified the sampling area to even out the coverage of our effort. This increased the number of sampling locations, particularly in Lake Ontario (Fig. 1). The effort was increased by 118% within this session compared to fall 1987 to improve our estimates for younger age-classes.

As in the past, walleye were captured with trapnets and marked with dorsal fin ray punches unique to this session (Bowlby and Mathers 1988). Because of the limited number of binary codes available, we chose to forgo unique marks for each location.

Population estimates of walleye were made for fall 1987 using the Jolly-Seber method (Ricker 1975) stratified by year-class. The 1986 year-class (1-year-old) was estimated using the adjusted Petersen method (Ricker 1975). Population estimates for spring and fall 1988 were made by subtracting the harvest and natural mortality from the estimates for the previous session. The natural mortality was assumed to be 20% for 1- and 2-year-olds and 35% for older fish and was assumed to occur on March 31.

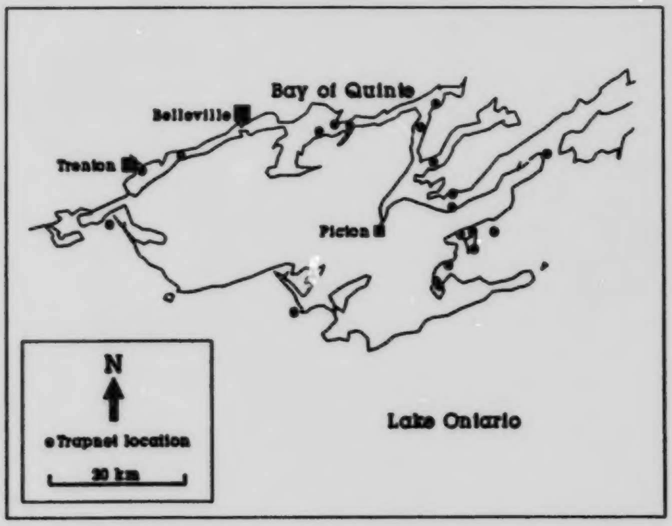

Figure 1. A map of eastern Lake Ontario and the Bay of Quinte showing the trapnet locations used during fall 1988 for mark-recapture of walleye.

POPULATION SIZE

The population estimate of 2-year-old and older walleye was 681488 during fall 1988. This population has declined 43% from 1985 to 1988 (Fig. 2). The main reason for this decline is related to the natural reduction in the unusually strong 1977 and 1978 year-classes (Table 1; see also Bowlby et al. 1989). These year-classes arose when competition and predation by older walleye and white perch were negligible and such conditions should not be expected in the near future (Bowlby et al. 1989). Rather, the population appears to be entering a range where we should anticipate some stability, providing harvests can be kept in balance with recruitment.

Table 1. The population of walleye in eastern Lake Ontario and the Bay of Quinte by year class from 1985 to 1988. population estimates were made with the Jolly-Seber method unless otherwise indicated.

Session	Year-class											
	75	76	77	78	79	80	81	82	83	84	85	86
Fall 85	50	150	328383	152930	40538	77967	186845	332921	69545	159180[1]		
Spring 86	3	5763	51968	312089	34502	64031	88948	224983	57628	159180[1]	357795[1]	
Fall 86	2	169	27861	159992	29377	28238	45574	171029	67130	127344	357795[1]	
Spring 87	837	200	36009	129896	36763	31807	48472	164120	88527	78318	286236	369244[1]
Fall 87	2	12	5297	121913	30162	18465	24105	78636	56216	79813	285163	369244[2]
Spring 88			3570	79988	19813	12075	15819	51622	36948	52320	228274	295395
Fall 88			3570	79112	19282	10159	13106	47832	28246	32460	170174	277542

[1] Calculated by adding losses to natural mortality to estimate below; natural mortality (20%) was assumed to occur on March 31.

[2] Calculated using adjusted Petersen method.

In addition, this is the first time that we have been able to make mark-recapture estimates of the number of 1-year-old walleye, and this is the first time that we have had any confidence in our estimates of 2-year-olds. These improved estimates of younger age-classes are a direct result of the changes in procedures, mentioned earlier. We expect further improvements of these estimates in the future.

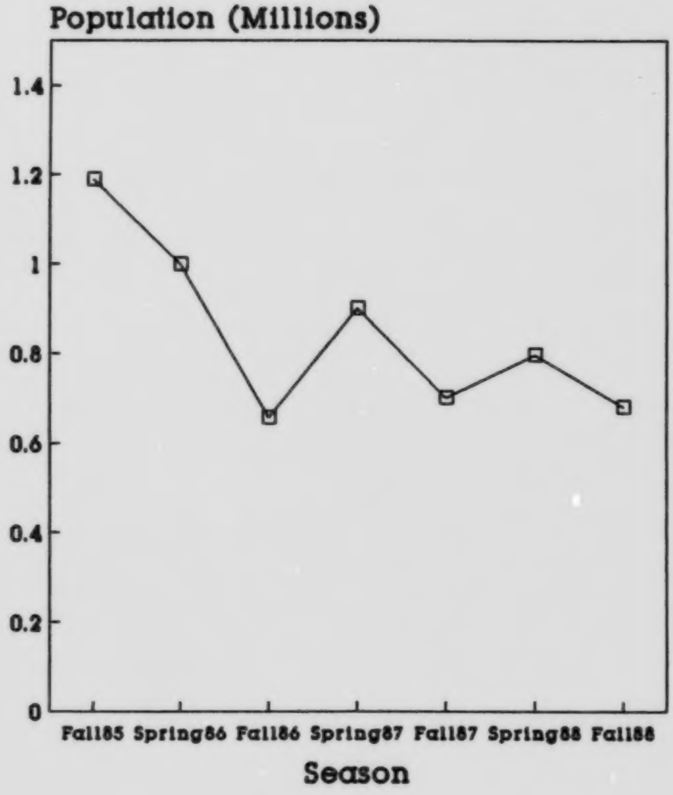

Figure 2. The estimated population of 2-year-old and older walleye in eastern Lake Ontario and the Bay of Quinte from 1985 to 1988.

AGE STRUCTURE AND YEAR-CLASS STRENGTH

The 1988 walleye year-class appears to be moderate in strength, based on catches of young-of-the-year (YOY) in Bay of Quinte research trawls (Fig. 3). Mean catches of YOY walleye were greatest in the Adolphus Reach (5.33 per tow), followed by Hay Bay (3.17 per tow) and then Big Bay (2.67 per tow). The relative importance of these areas in producing strong year-classes of walleye is still not clear. The 1977 and 1978 year-classes were for a large part produced in the Bay of Quinte near Trenton and Bellville, and these sites are no longer indexed be the research trawl program (Bowbly et al. 1989). The research trawl program was not intended to index YOY walleye.

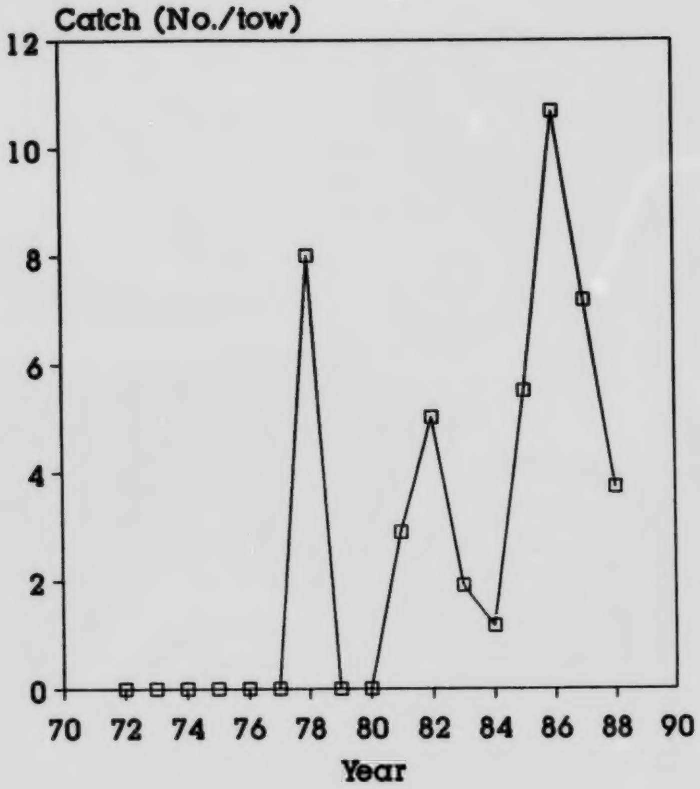

Figure 3. The mean catch of YOY walleye in Glenora Fisheries Station research trawls from 1972 to 1988. The mean is combined for sites at Big Bay, Hay Bay, and the Adulphus Reach (Conway).

The catch of YOY walleye in the research trawls shows promise as a predictor of population size. Since 1981, the catch of YOY walleye has been highly correlated with the population of 2-year-old walleye in eastern Lake Ontario (Fig. 4). However, inclusion of the the 1977 to 1980 data reduces this correlation greatly. These earlier years were at the beginning of the walleye recovery when density-dependent effects may not have been pronouced. Also, we have less faith in our population estimates for earlier years. Because the clarity of this relationship remains in question, further sampling must be done to confirm its utility for predictive purposes.

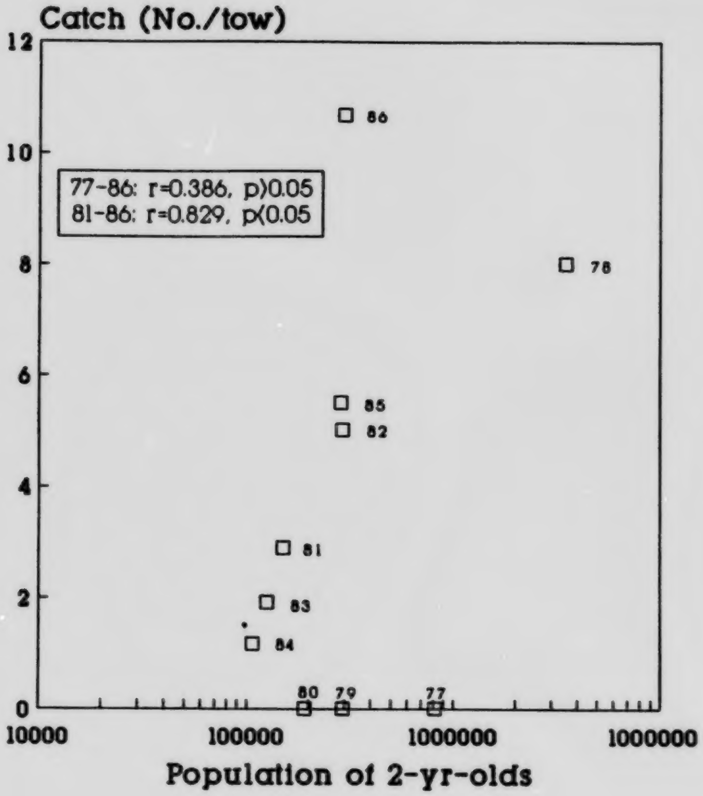

Figure 4. The relationship between the catch of YOY walleye in research trawls and the population of 2-year-old walleye of the same year-class in eastern Lake Ontario. Numbers beside the squares indicate the year-class.

The 1987 and 1988 age distributions of walleye illustrate the prominence of strong year-classes in the population through time (Fig. 4). For instance the strong 1978 and 1982 year-classes dominated the population of mature walleye. However, the population as a whole in 1988 was dominated by 1-, 2-, and 3-year-old fish (Fig. 5). The current age distribution suggests that the population is stable and healthy under the current level of exploitation.

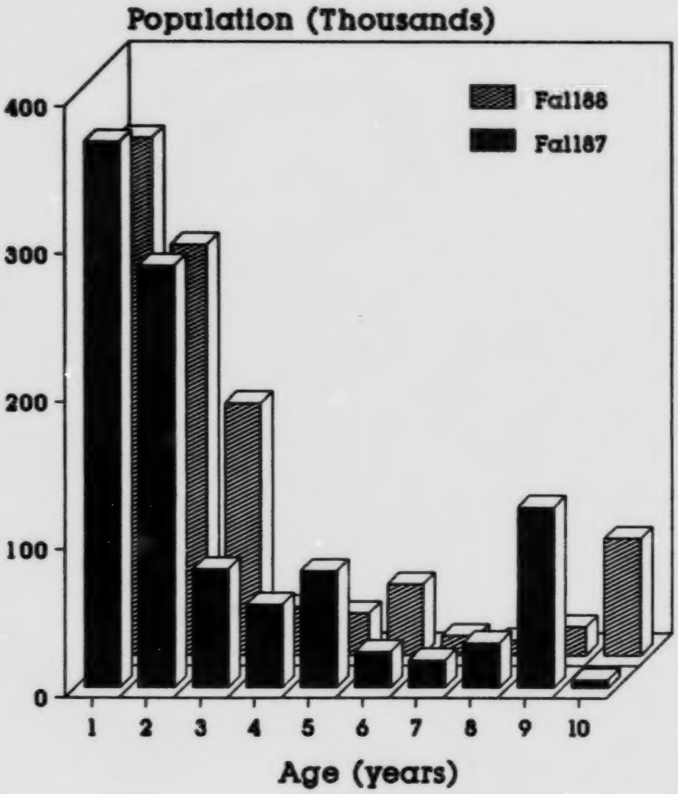

Figure 5. The age distribution of walleye in eastern Lake Ontario and the Bay of Quinte during fall 1987 and fall 1988.

HARVEST AND POPULATION RELATIONSHIPS

Mathers (1989) detailed the harvest of walleye by anglers in the Bay of Quinte during 1988. The summer (open water) catch was spread out fairly evenly among 1-, 2-, and 3-year-olds, whereas, the harvest was dominated by 3-year-olds (Fig. 6). Most of the 1- and 2-year-olds were released. However, anglers had the greatest impact on 4-year-olds, harvesting close to 40% of them in the summer fishery (Fig. 7). Certainly the harvest would have been greater if 4-year-olds had been more abundant. Given the current strong year-classes of 1-, 2-, and 3-year-olds (Fig. 3 and 5) we should expect an increased harvest in 1989.

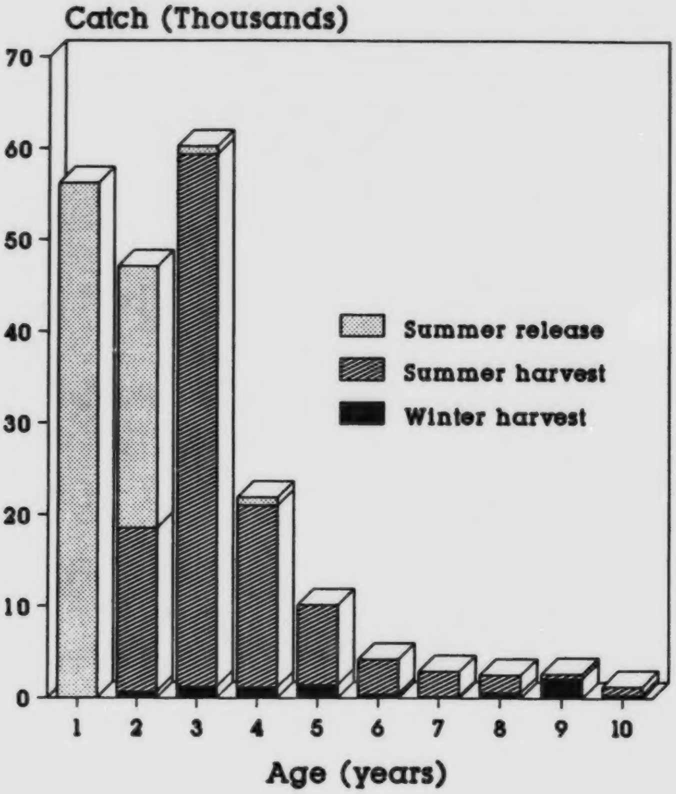

Figure 6. The age distribution of the catch of walleye by anglers in the winter (on ice) and summer (open water) fisheries during 1988 in the Bay of Quinte. Note that because walleye ages are incremented on April 1, the winter and summer catches for a single age class are composed of two year-classes.

The winter (on ice) harvest was much lower than in summer. The age distribution of the winter harvest (Fig. 6) reflected the age distribution of the population (Fig. 4: 1987; walleye ages increment on April 1). Accordingly, anglers harvest walleye, older than 2 years, in proportion to their abundance in this fishery.

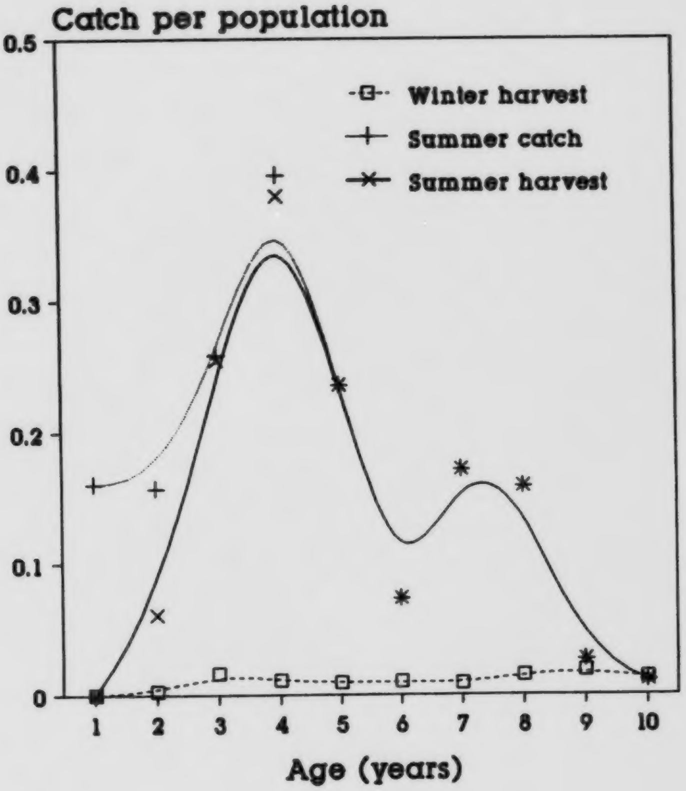

Figure 7. Selectivity of anglers for walleye in summer and winter fisheries in the Bay of Quinte during 1988. The the trend lines are fitted by a moving average.

ACKNOWEDGEMENTS

We thank Kendall Dewey and the employees of KJB Biotech for their their high standards in completing the field work, Kelly Garbutt for data entry and verification, Jeff Church for aging walleye scales, Bill Dentry and Ted Schaner for reviewing an earlier draft, and Carol Ward and Linda Corbett for copy editting and reproduction.

REFERENCES

BOWLBY, J.N., AND A. MATHERS. 1988. Walleye populations in eastern Lake Ontario and the Bay of Quinte, 1987. *In* Lake Ontario Fisheries Unit 1987 Annual Report. Chapter 1. LOA 88.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J.N., AND A. MATHERS. 1989. Lake Ontario walleye harvest management model. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 10. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J.N., A. MATHERS, AND D. A. Hurley. 1989. The status of walleye in the Canadian waters of Lake Ontario. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 9. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

MATHERS, A. 1989. Bay of Quinte angling surveys, 1988. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 2. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Reasearch Board of Canada. Bulletin 191:1-382.

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March 21-22, 1989
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THE RESURGENCE OF WALLEYE IN THE CANADIAN WATERS OF LAKE ONTARIO[1]

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ABSTRACT

Since 1978, the estimated population of walleye (aged 1 and older) in eastern Lake Ontario has varied from about 1,000,000 to 5,000,000. In the prior decade the population had declined to extremely low levels as a result of eutrophication of spawning and nursery habitat. The 1977 and 1978 year-classes were the largest in the last 20 years. The population peaked in 1979 when it was dominated by these two year-classes and has since declined because of a succession of a number of weaker year-classes. However, since 1984 this population has remained relatively constant. Estimates of total annual mortality of walleye in eastern Lake Ontario ranged from 36 to 56%, but the true value is likely in the vicinity of 40% for adult walleye. Growth rates and maturation schedules of walleye in the Bay of Quinte have not changed appreciably between the the 1960s and the 1980s. A problem in aging scales particularly from 1978 to 1987 has delayed a complete growth analysis. Nevertheless, we have detected density-dependent effects of the same year- class and the two previous year-classes on these growth rates. Recruitment of walleye in eastern Lake Ontario over a broad spectrum of adult (aged 4 and older) population size appears to be governed by density-dependent factors following a Ricker model. However, since 1985 the population has stabilized to a rather narrow range, and within this range the Ricker model explains little compared to other sources of error. Adult alewife has been the major food item of walleye over 30 cm in the Bay of Quinte since the 1950s. The resurgence of walleye appeared to be centred in the upper Bay of Quinte based on young-of-the-year (YOY) catches in 1977 and 1978. In later years the lower Bay of Quinte had higher densities of YOY. The catch of larger walleye during summer in index gillnets showed a lagged but similar trend of distribution through time. Mature walleye move from the Bay of Quinte to Lake Ontario after spawning during spring, and return to the bay during fall. In general, the trends in catch and harvest have followed the population trends. The current harvest-per-effort (CPE) is similar to the late 1950s.

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1. This is a draft of a paper written for the GLFC Walleye Rehabilitation Workshop.

RECOMMENDATIONS

1. Resolve aging problem, and make a complete analysis of growth through time and by location.

2. Continue recruitment modelling efforts, but incorporate age structured density-dependent effects, and environmental effects for variables such as water temperature and river discharge.

INTRODUCTION

Walleye (*Stizostedion vitreum*) declined in eastern Lake Ontario and the Bay of Quinte during the 1960s, but rebounded after 1977 (Hurley and Christie 1977; Hurley 1986a). This decline was associated with an increase in white perch (*Morone americana*), and excessive eutrophication, rather than overexploitation (Hurley and Christie 1977). After improvements in domestic sewage treatment, which reduced eutrophication, and a large decline of white perch, strong year-classes of walleye were produced in 1977 and 1978 (Hurley 1986a). In this paper we describe the resurgence of walleye in eastern Lake Ontario and the Bay of Quinte since 1977. As well, we compare the current population with that of the the late 1950s and early 1960s to provide some insights into this resurgence.

Most walleye in Lake Ontario are associated with the Bay of Quinte (Fig. 1) because of suitable habitat for all life stages, and because major spawning areas of Lake Ontario walleye are rivers that flow into the bay (Trent R., Moira R., Salmon R., Napanee R.). Walleye may spawn also on shoals and in several smaller streams around the lake. Historically, Hay Bay had the greatest number of shoal spawners in the Bay of Quinte (Payne 1963), and more recently, large numbers of walleye have been observed spawning in Hay Bay (D. Jones, OMNR Napanee District, personal communication). However, the current contribution of walleye from these shoals and smaller streams to the total lake population is, for the most part, poorly known. Walleye marking studies indicate considerable movement between the Bay of Quinte and Lake Ontario (as far away as the St. Lawrence River, Black River and Chaumont Bay in New York). Also, walleye marked during spawning at one river have been recaptured during spawning in another year at another river (Lake Ontario Fisheries Unit, unpublished data). Based on these returns we now treat eastern Lake Ontario and Bay of Quinte walleye as one large population with several rather loose components formed by fish that spawn in various places. Other smaller stocks of walleye are located around the perimeter of the lake where habitat is suitable, for instance, at the mouth of the Niagara River, and some of the other rivers entering the lake.

DATA SOURCES

The data used for in this paper comes primarily from fisheries assessment and research programs at the Lake Ontario Fisheries Unit, Glenora Fisheries Station. A brief description of these programs follow.

Walleye Mark-recapture Program

Results presented here are based on walleye batch-marked since 1985. Although this program has been running for a longer period, insufficient walleye were marked and recaptured previously to make age specific population estimates. Mark-recapture sessions were run during spring and fall from 1985 to 1987 and during fall 1988. The number of walleye observed during each of these sessions ranged from 7053 during fall 1986 to 13834 during fall 1988. All marked and recaptured walleye were caught in trapnets at various locations throughout the Bay of Quinte and in Lake Ontario adjacent to Prince Edward County (Fig. 1). Population estimates for each year-class used the Jolly-Seber method (Ricker 1975) to provide age-specific estimates.

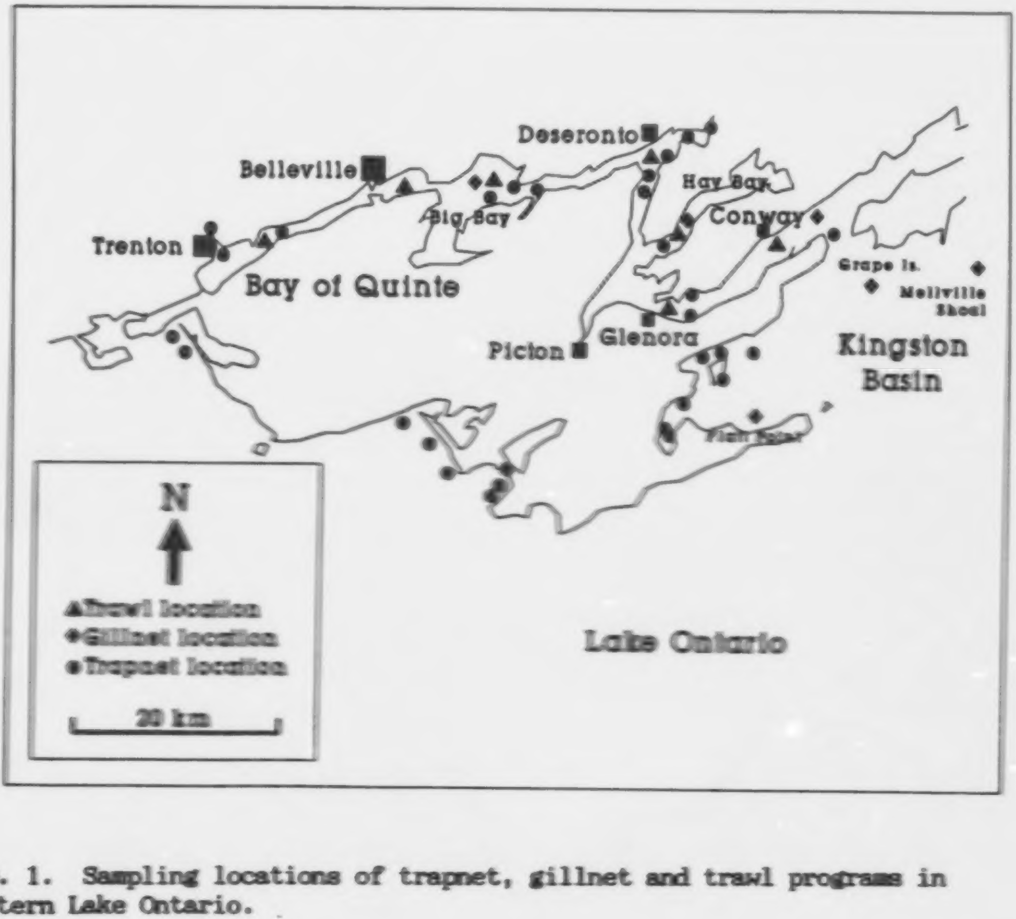
Deseronto
Belleville
Hay Bay
Big Bay
Conway
Trenton
Bay of Quinte
Grape Is.
Mellville Shoal
Picton
Glenora
Kingston Basin
Flat Point
N
▲Trawl location
◆Gillnet location
●Trapnet location
20 km
Lake Ontario

FIG. 1. Sampling locations of trapnet, gillnet and trawl programs in eastern Lake Ontario.

Lake Ontario Nearshore Gillnet Program

During 1983 to 1985 this program was conducted at two sites in the Kingston basin of Lake Ontario (Fig. 1). During this period a graded mesh series of gillnets (3.81 cm to 12.7 cm by 1.27 cm intervals) were set twice per month at a depth of 10 m. Only data from August were used here. During 1986 to 1988 this program was conducted at three sites in the Kingston basin during August (Fig. 1). The same graded mesh series was set three times per month at 5 m depth intervals from 2.5 to 27.5 m. Only data from the 7.5 and 12.5 m intervals were used here. All lifts had an effort of 1 night.

Bay of Quinte Gillnet Program

A graded mesh series of gillnets similar to the above program was used, except the mesh depth was shallower to correspond to the shallower depths in the Bay of Quinte. Data used here came from three sites (Fig. 1), and were collected during June, July, and August. The site at Hay Bay has been sampled almost continuously from 1958 to present. Big Bay and Conway have been sampled since 1972 and 1975 respectively. All lifts had an effort of 1 night.

Bay of Quinte Trawl Program

Bottom trawls were made monthly from May to September starting in 1972 at seven locations (Fig. 1). Since 1981 trawls were made at only three of these locations. The net had an opening of 6 m and a cod end with 1.27 cm (0.5 inch) mesh. Tows were 400 m in distance at a speed of 1.1 m/sec.

Bay of Quinte Angling Surveys

Twenty-four angling surveys during the open water season and four surveys during ice cover have been conducted on the Bay of Quinte since 1957. The surveys combined angling activity counts with interviews conducted with anglers on the water. Surveys had a stratified, random design and employed boat counts and roving interviews. The angling surveys were stratified by space, day-type (weekends and weekdays), and season to reduce the variance of the angling effort and harvest estimates. These angling surveys covered the Bay of Quinte from Trenton to Glenora (Fig. 1).

Commercial Catch Data

Baldwin et al. (1979) published walleye landings. Commercial catch totals after 1977 came from Annual Reports of the Lake Ontario Committee to the Great Lakes Fishery Commission.

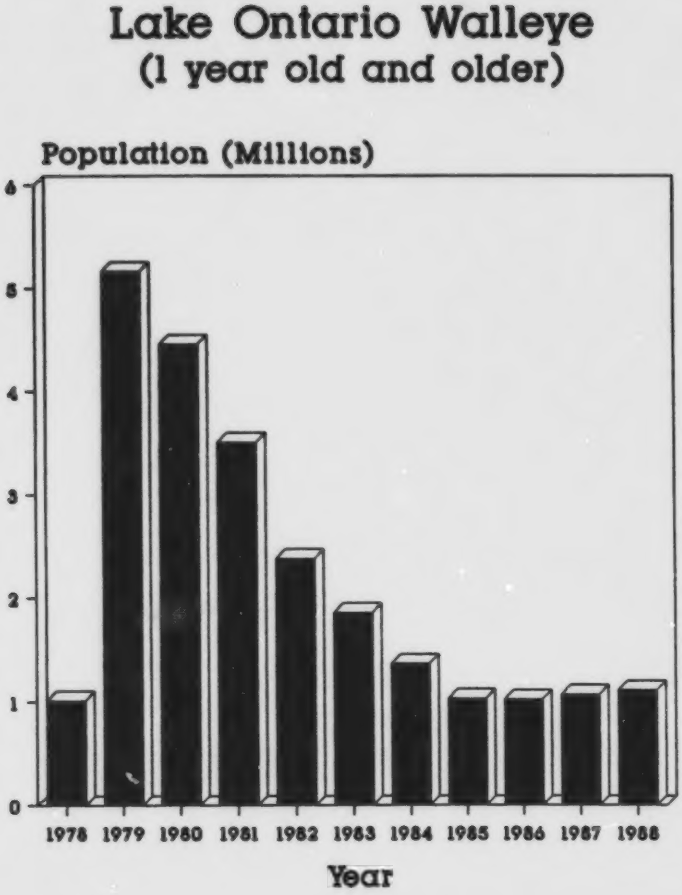

FIG. 2. Population estimates of 1-year-old and older walleye in eastern Lake Ontario during fall from 1978 to 1988. These estimates based on age stratified Jolly-Seber estimates for fall 1987. Other years have been forecast or backcast from the 1987 estimates using annual total mortalities of 20% for age 1, 25% for age 2 and 40% for all older ages.

POPULATION STUDIES

Population Status

Since 1978, the estimated population of walleye (aged 1 and older) in eastern Lake Ontario has varied from about 1,000,000 to 5,000,000 (Fig. 2). The population is consistent with the pattern of year-class strength indicated by the catch of young-of-year (YOY) walleye in the Bay of Quinte bottom trawls (Fig. 3), by the estimated number of two year olds (Fig. 4), and by the catch-per-effort (CPE) of one to four year olds from the same year-class in Bay of Quinte gillnets (Fig. 5). Population estimates and CPEs indicated that the

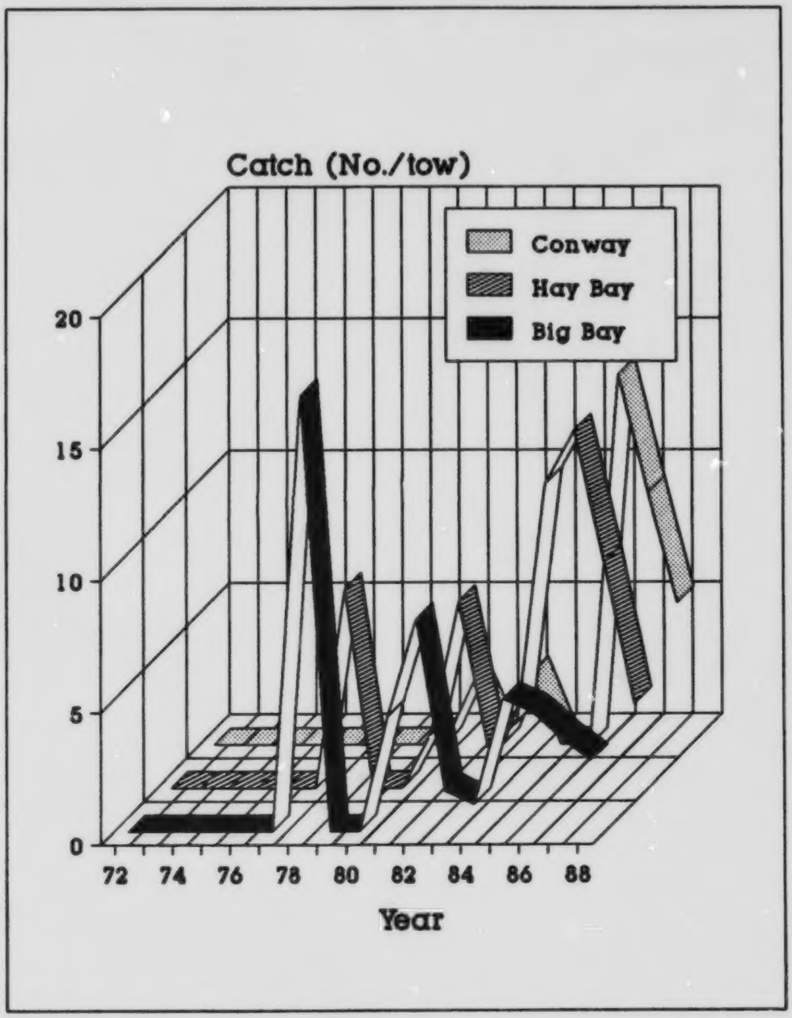

FIG. 3. Mean catch of young-of-year walleye in trawls in the Bay of Quinte, Lake Ontario during August and September, 1972-1987.

1977 and 1978 year-classes were the largest in the last 20 years. The population peaked in 1979 when it was dominated by these two year-classes and has since declined because of a succession of a number of weaker year-classes. However, since 1984 this population has remained relatively constant (Fig. 2).

CPE in Hay Bay index gillnets indicate that walleye populations during the late 1950s and early 1960s were of the same order of magnitude compared with the more recent populations (Fig. 6). These nets also document the decline in the population during the late 1960s and the low population throughout most of the 1970s.

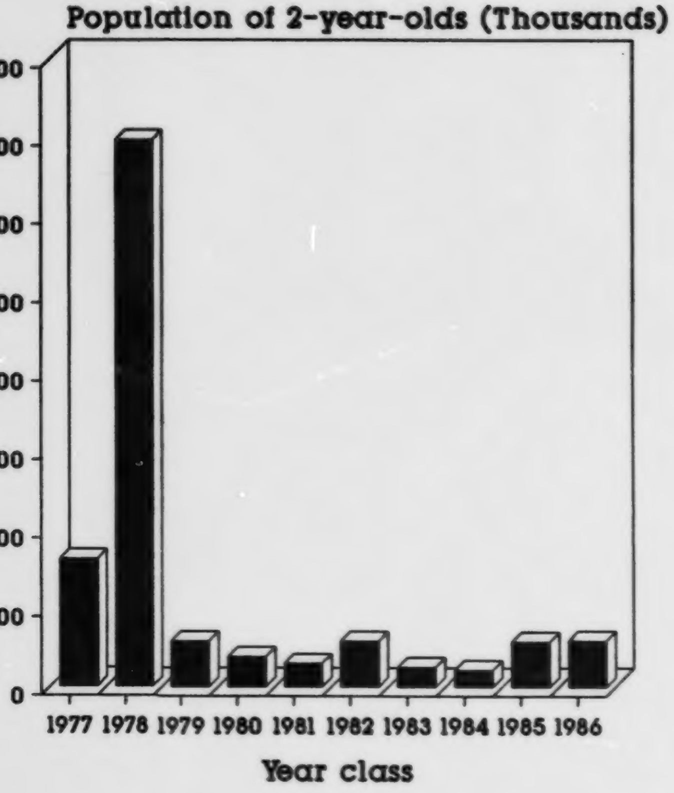

FIG. 4. Estimated population of 2-year-old walleye for 1977 to 1986 year-classes in eastern Lake Ontario. Estimates were calculated as for Fig. 2.

Total Mortality

Estimates of total annual mortality of walleye in eastern Lake Ontario ranged from 36 to 56 % (Table 1). The post 1977 catch curve estimates may be biased high due to the effects of the strong 1978 year-class in the population. Also, the method based on tag returns may have overestimated mortality because of tag loss. We have greatest confidence in the method based on Jolly-Seber population estimates and feel the true mortality is in the vicinity of 40% for adult walleye. Younger walleye likely have lower total mortality because they are subject to low angling mortality and natural mortality. Specifically, most one- and two-year-old walleye are released by anglers. Also immature walleye are not subject to spawning related mortality (natural and by poachers).

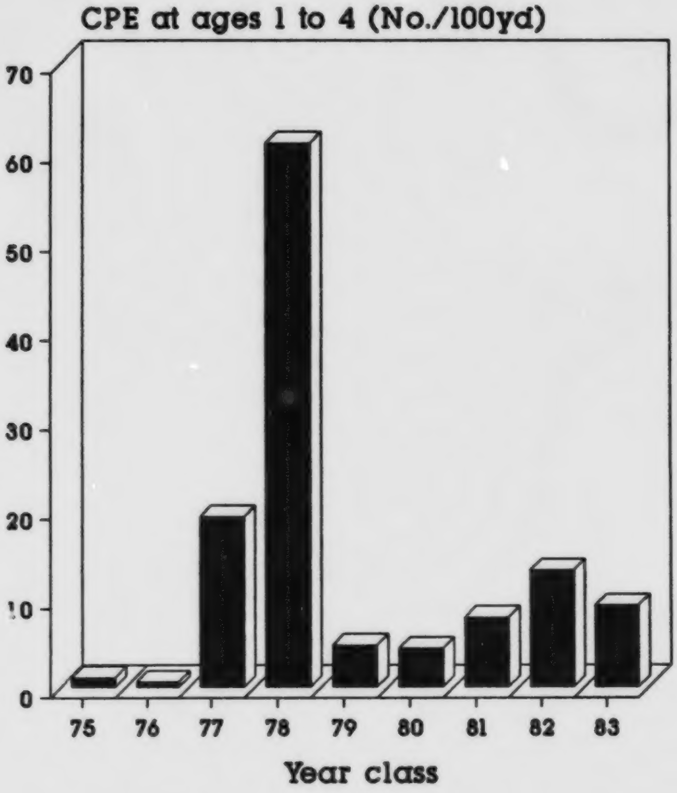

FIG. 5. An index of walleye year-class strength calculated as the sum of CPE (No./100 yd) of index gillnets for age 1 to age 4 walleye in the same year-class.

Table 1. Estimates of instantaneous total mortality (Z) and actual annual mortality (A) of eastern Lake Ontario walleye.

Source	Year	Z	A
Trapnet catch curve	1957-1962[1]	0.46	0.37
Gillnet catch curve	1958-1962[1]	0.77	0.54
Gillnet catch curve	1977-1984	0.69	0.50
Trapnet catch curve	1980-1985	0.75	0.54
Tag returns from angling	1980-1984	0.83	0.56
Age-specific Jolly-Seber			
population estimates (fall)	1985-1987	0.63	0.47
(spring)	1986-1987	0.44	0.36

1 - calculated from data in Payne (1963)

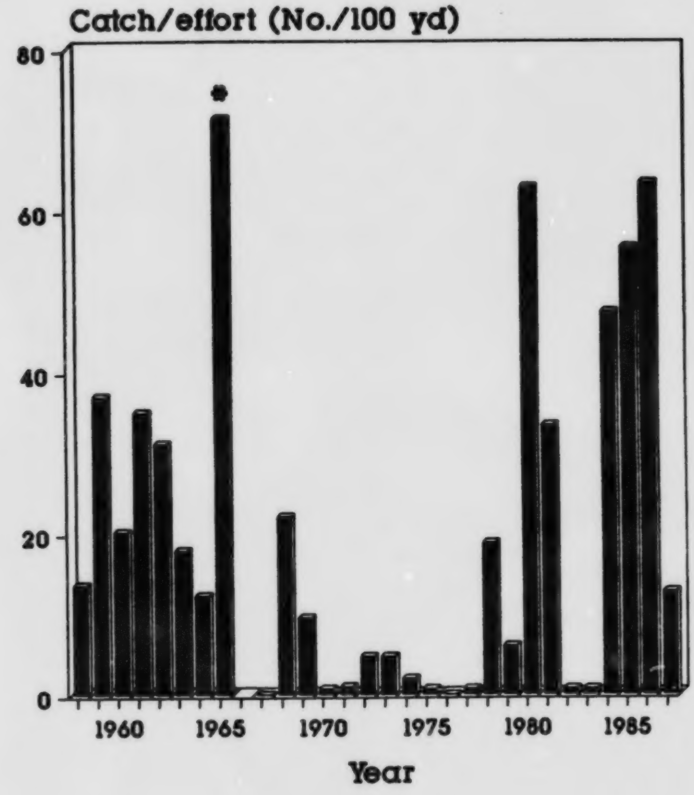

FIG. 6. Average number of walleye caught per gillnet lift at Hay Bay for June through August, 1958 - 1987. A lift was defined as one night of effort for a net consisting of 100 yd (91.4 m) of 1.5, 2, 2.5, 3, 3.5, 4, 4.5 inch (3.8, 5.1, 6.4, 7.6, 8.9, 10.2, 11.4 cm).

Growth and Maturity

Growth rates of walleye in eastern Lake Ontario (Fig. 7) are quite similar to the faster growing stocks in Lake Huron (Spangler et al. 1977). Payne (1963) found that walleye from the upper Bay of Quinte (Trenton to Deseronto, Fig. 1) grew slower than those from the lower Bay , particularly Hay Bay (Fig. 7). Because the growth is parallel in these two areas, the differences in growth rate of walleye from these areas may be set during the first year of life. More recent data integrates these areas but shows relatively little difference between the historic and current growth rates (Fig. 7). The earlier data (1957-1962) was collected during spring, whereas the later data (1987-1988) was collected during fall. One year of age was added to the fall data for direct comparison to the spring data on the assumption

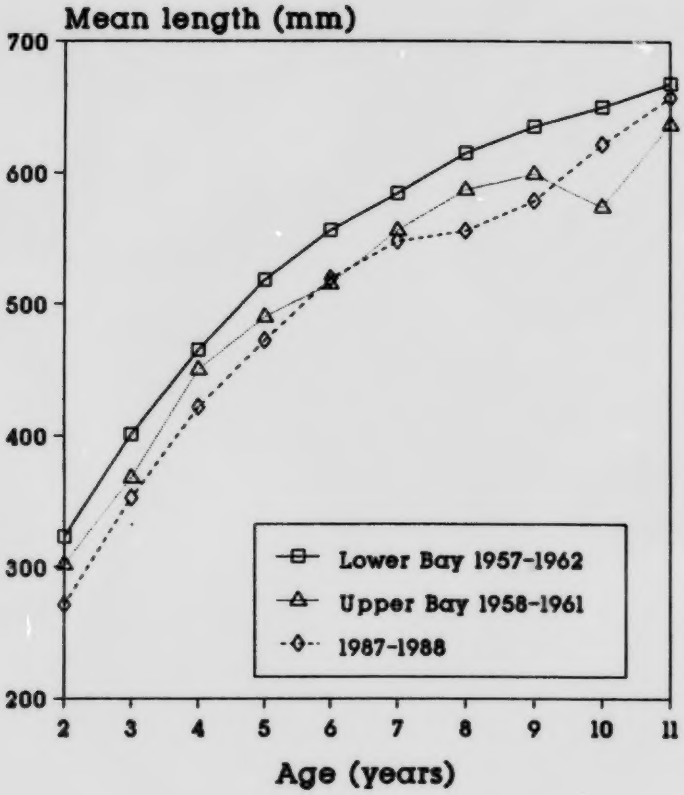

FIG. 7. Growth of walleye taken in trapnets in eastern Lake Ontario. The lower bay data were collected primarily from Hay Bay; the upper bay data were collected from Belleville to Trenton (Fig. 1), and both of these datasets were summarized by Payne (1963). The 1987-1988 data were collected throughout the Bay of Quinte and in eastern Lake Ontario (Fig. 1).

that seasonal growth had ceased by the time the fish were sampled. However, if this assumption is false then slight differences between the historic and more recent data might be reduced (Fig. 7).

We have discovered a bias in the ages assigned to some eastern Lake Ontario walleye scales in some years and so a complete analysis for all years (i.e. 1978-1986) and spring *versus* spring comparisons are not available. These scales tend to have been underaged by one year. An analysis of this problem in age determination for the 1980s data showed that almost all the walleye scales in a strong year-class were underaged by one year, but a smaller portion of the scales of weak age-classes were underaged. Accordingly, one should not simply add one to correct the age of a fish. Apparently, the criteria used by agers to determine annuli did not account for the first annulus in some cases. A cursory examination of these scales suggests that the less distinct first annulus of strong year-classes was likely a function of density-dependent growth. Further analysis is required to test this hypothesis.

The growth rate of walleye in a particular year-class was found to be a function of the densities of the same year-class, the previous year-class and the year-class 2 years previous. To determine this relationship, first, the mean length at age of eastern Lake Ontario walleye caught in fall 1987 in trapnets was fit to the von Bertalanffy growth equation (Ricker 1975) as follows: fork length = $875.6(1-e^{-0.1096(age+3.038)})$ ($R^2=0.999$; $F=1636$, $P<0.0001$). Second, the residuals from this equation were related to an index of year-class strength for the same year-class the previous year-class and the year-class 2 years previous. For this index we used the density of young-of-year walleye in trawls from Hay Bay. Data from Hay Bay was chosen over other locations by stepwise regression. The previous year-class had the greatest depressing effect on growth rate, followed by the year-class 2 years previous, and the same year-class (Table 2).

Table 2. The relationship between indices of year-class strength and the residuals from the mean length at age and von Bertalanffy growth curve in Fig. 7 for walleye caught during fall in trapnets in eastern Lake Ontario. The analysis was a multiple regression that explained 85% of the the variation in the residuals (F=9.22, P=0.018).

Source variable	Regression Coefficient	F	P
Same year-class	-1.199	4.58	0.043
Previous year-class	-3.307	13.52	0.007
Year-class 2 years previous	-2.687	8.76	0.016

In eastern Lake Ontario, most female walleye mature at age 4, whereas most males mature at ages 2 to 3 (Fig. 8). Payne (1963) also found that in the Bay of Quinte most female walleye matured at age 4 and males matured at age 2 to 3 and so there has been no change in the maturation schedule.

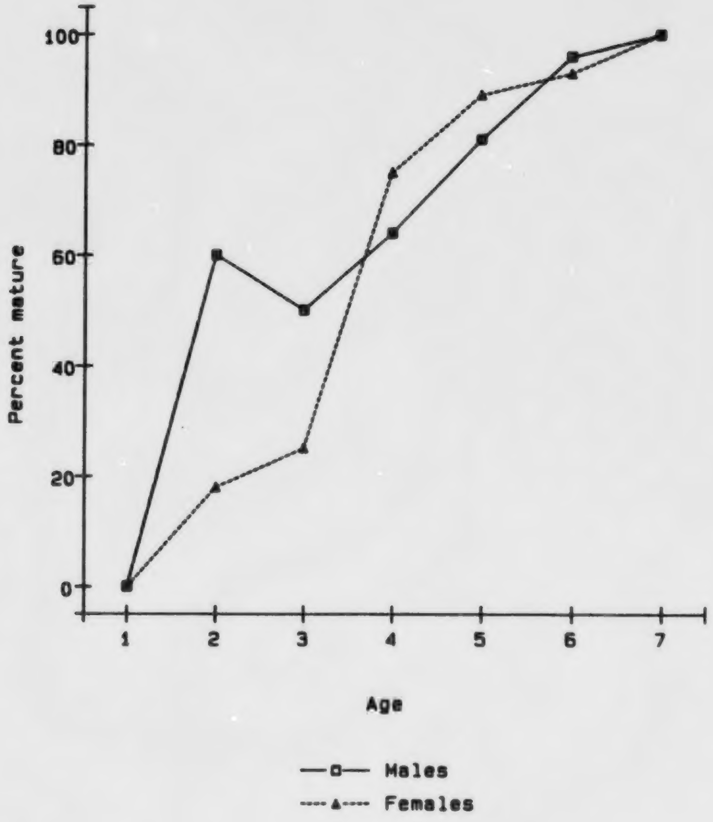

FIG. 8. The expected percent mature walleye by age and sex at spawning time in the Bay of Quinte, Lake Ontario. Samples were taken from gillnets from 1977-1987.

Recruitment

Recruitment of walleye in eastern Lake Ontario over a broad spectrum of adult (aged 4 and older) population size appears to be governed by density-dependent factors. The recent resurgence in walleye has provided a large variation in adult walleye populations which is rarely available to adequately test for such a relationship. The following Ricker stock recruitment relationship (Ricker 1975) was developed for eastern Lake Ontario walleye (Fig. 9): $\log_{10}(\text{number of 2-year-olds}) = 56.4 \cdot \log_{10}(\text{adults}) e^{-0.26 \log_{10}(\text{adults})}$ ($R^2=0.997$; $F=1459$, $P<0.0001$). The shape of this curve outside the minimum and maximum recorded adult populations is unimportant because they represent levels which are unlikely to be seen again barring a major environmental or community shift in Lake Ontario. The important result here is the

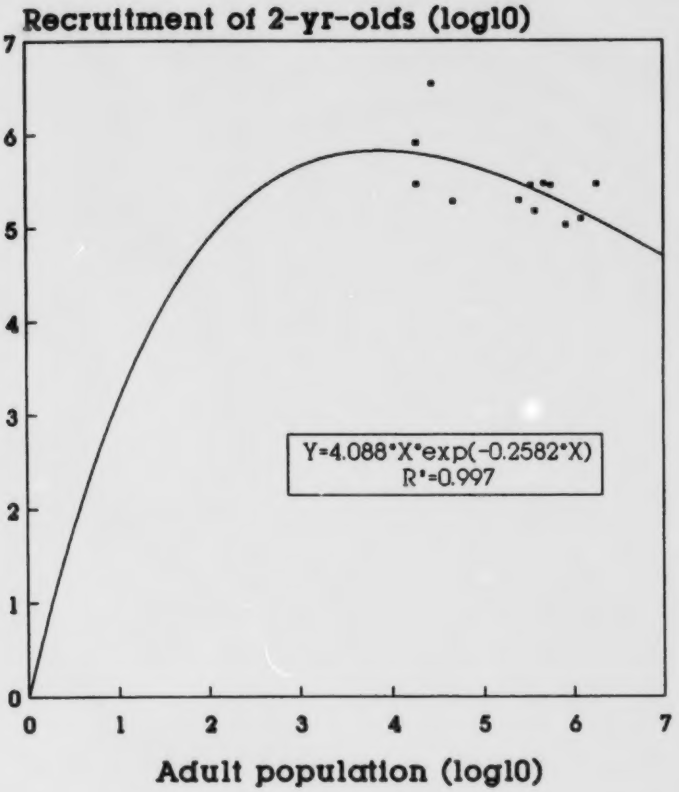

FIG. 9. The number of 2-year-old walleye produced by the number of adult walleye (aged 4 and older). Data are for year-classes produced during 1977-1988. The fitted function is the Ricker stock-recruitment equation.

decreasing trend in the portion of the curve occupied by the data (Fig. 9). However, since 1985 the population has stabilized to a rather narrow range (Fig. 2). Within this range the Ricker model explains little compared to other sources of error (Fig. 9). Above we suggested that the two preceeding year-classes influenced growth of walleye, but the analysis here does not include them. Hurley (1986a) has suggested that the density of white perch may influence year-class strength of walleye in the Bay of Quinte. As well, weather patterns and water temperatures near the time of hatch generally have a strong influence on walleye recruitment (Colby et al. 1979). However, Hurley (1986a) found no relationship between walleye year-class strength and spring water temperature conditions in the Bay of Quinte. Combining the environmental effects with the population and community effects in our modelling might reveal these relationships.

FOOD

Adult alewife (*Alosa pseudoharengus*) is the major food item of walleye over 30 cm in the Bay of Quinte (Table 3). Rainbow smelt (*Osmerus mordax*) became more important in the diet during the late 1970s when the alewife population was low (Ridgway et al. 1988), particularly in the deeper areas east of Glenora. For the most part, however, the walleye diet has changed little through time (Table 3).

Table 3. The percent occurrence of food in walleye from the Bay of Quinte during three time periods. The numbers in parentheses indicate the sample size of walleye stomachs examined.

Food item	1958-1962[a] (721)	1977-1981[b] (589)	1987 (112)
Alewife	52.1	28.5	48.2
Rainbow smelt	1.9	15.6	1.8
Yellow perch	0.4	3.9	.
White perch	0.1	1.2	0.9
Minnow	0.1	.	.
Johnny darter	.	0.7	.
Gizzard shad	.	0.7	.
Sculpin	.	0.2	0.9
Stickleback	.	0.2	.
Unidentified fish	48.7	53.0	39.3
Fish eggs	0.6	.	.
Insects	0.3	1.9	16.1
Chironomidae	.	2.0	.

a - Calculated from Hurley and Christie (1977).
b - Hurley (1986a)

DISTRIBUTION

The resurgence of walleye appeared to be centered in the upper Bay of Quinte. In 1978, 47.5 and 86.5 YOY were caught on average in trawl nets near Trenton and Belleville (Fig. 1), respectively. YOY densities were much lower at sites farther down the Bay of Quinte. In later years the lower Bay of Quinte had higher densities of young-of-year. The catch of larger walleye during summer in index gillnets showed a similar trend of distribution through time. From 1981 to 1987 walleye CPE decreased at upper Bay of Quinte sites but increased at lower Bay of Quinte and Lake Ontario sites (Fig. 10 and 11). In 1987, walleye CPE was higher at some sites in Lake Ontario than in the Bay of Quinte (Fig. 10 and 11).

Table 4. The mean catch per tow of YOY walleye in trawls in the Bay of Quinte during August and September.

	Location						
Year	Trenton	Belleville	Big Bay	Deseronto	Hay Bay	Glenora	Conway
1972	0.5	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.5	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	1.5	1.5	0.0	0.0	0.0	0.0	0.0
1978	47.5	86.5	16.5	36.0	7.5	1.0	0.0
1979	0.0	1.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.5	0.0	0.0	0.0
1981	.	.	4.3	.	2.0	.	2.3
1982	.	.	8.0	.	7.0	.	0.0
1983	.	.	1.5	.	1.5	.	2.7
1984	.	.	1.0	.	2.5	.	0.0
1985	.	.	5.0	.	11.5	.	0.0
1986	.	.	4.5	.	13.5	.	14.0
1987	.	.	3.5	.	8.5	.	9.5
1988	.	.	2.7	.	3.2	.	5.3

Payne (1963) suggested that mature walleye moved from the Bay of Quinte to Lake Ontario after spawning during spring. They returned to the bay during fall. Although we have made no rigorous analysis of movements, recent mark/recapture data and index gillnet data appear consistent with movement patterns suggested by Payne (1963). We have had tag returns of Bay of Quinte marked walleye as far away as the St Lawrence River, the Oswegatchie River, Chaumont Bay, and the Black River (New York). Moreover, our mark/recapture data regularly shows movements of walleye between the Bay of Quinte and Lake Ontario. Otherwise, relatively little effort is directed towards walleye outside of the Bay of Quinte during summer, and so recapture information from Lake Ontario is minimal. However, during summer index gillnets in the Bay of Quinte fail to catch large walleye that are known to be in the population by mark/recapture studies (Fig. 12a and 12b). This suggests that they had moved elsewhere. Walleye may move out the Bay of Quinte in response to low food abundance (Ridgway et al. 1988), or perhaps in response to higher water temperatures in the bay.

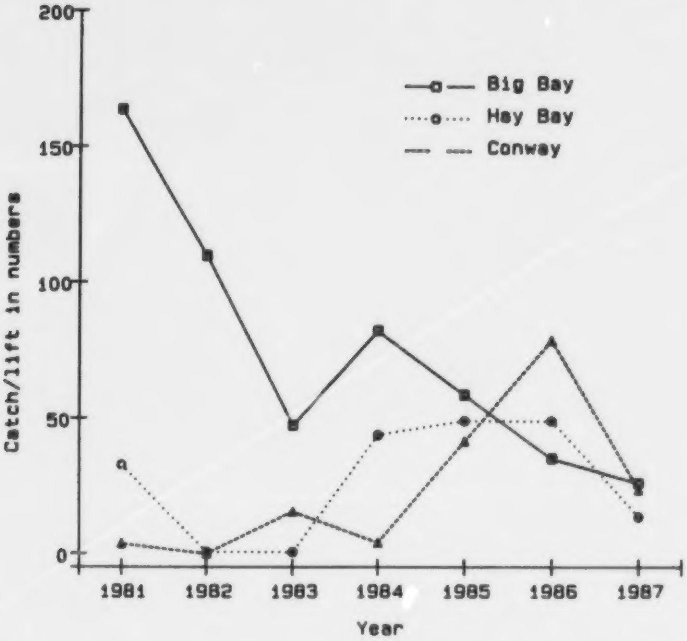

FIG. 10. Average number of walleye caught per gillnet lift in the Bay of Quinte, Lake Ontario, for May through September, 1981-1987.

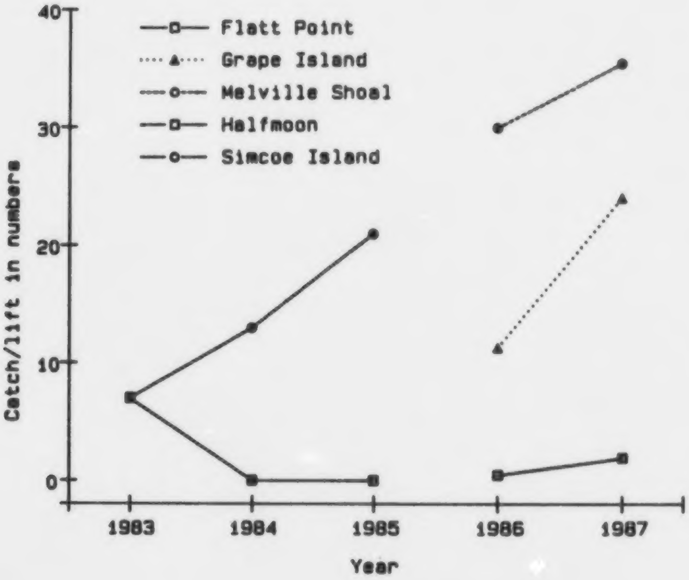

FIG. 11. Average number of walleye caught per gillnet lift in Lake Ontario, during August, 1983-1987. Methods differed prior to, and after 1985.

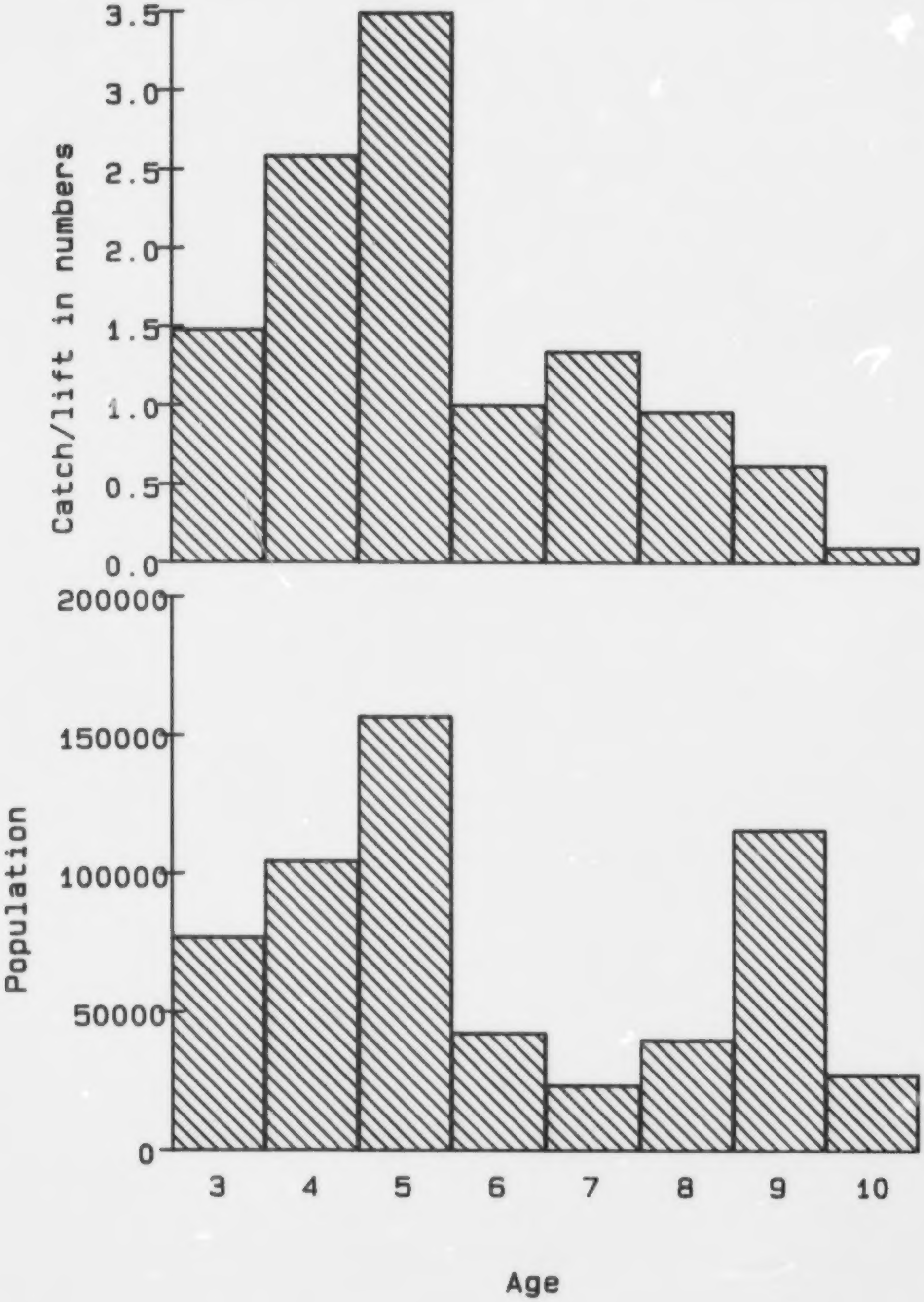

FIG. 12. Age distributions of walleye in eastern Lake Ontario during 1987: a) average catch per standard lift of gillnets in Hay Bay, and b) based on age-specific population estimates.

Walleye in the Kingston basin of Lake Ontario during August are more abundant at depths less than 15 m and at temperatures near 20°C (Fig. 13). Accordingly, outside the Kingston basin and a few sheltered bays most of Lake Ontario is not considered suitable habitat for walleye.

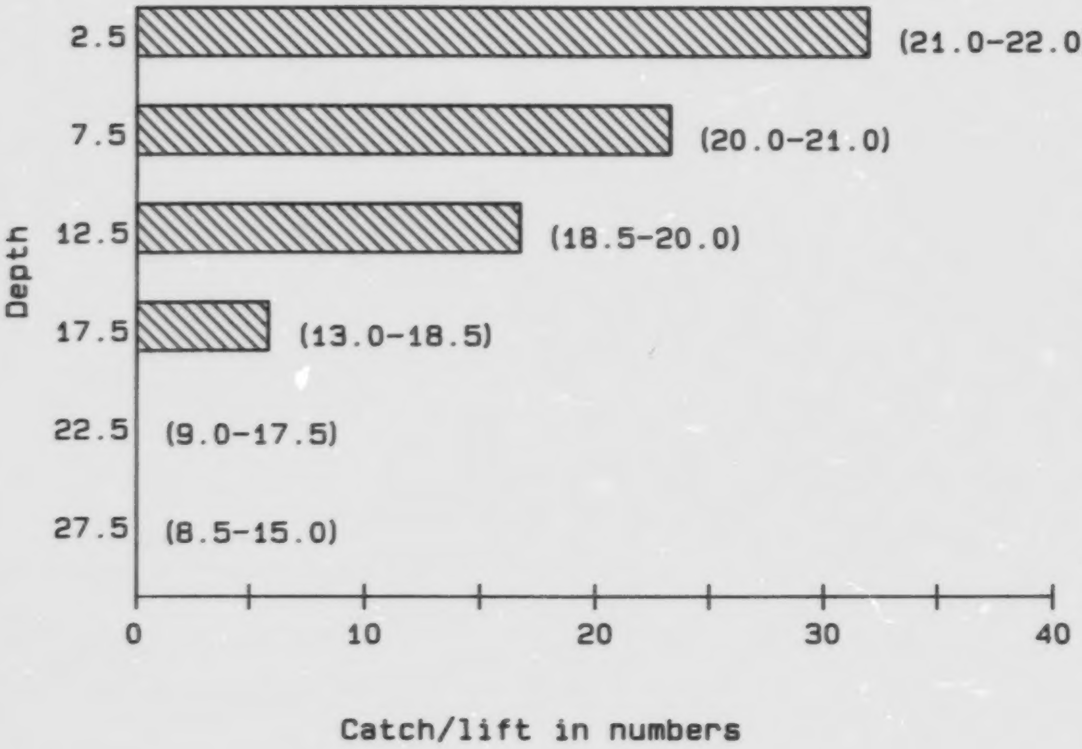

FIG. 13. Depth distribution of walleye at Grape Island, Lake Ontario during August 1987. Numbers in parentheses are the temperature range for three sets.

HARVEST

In the past, angling and commercial fisheries have been the major harvesters of walleye in Lake Ontario (Fig. 14). Prior to 1970, commercial harvest dominated, but since the resurgence of the population angling harvest has dominated the fishery. This change, in part, has been the result of regulations to limit the catch of walleye by commercial industry (Table 5). In 1981 commercial fishermen were given a small quota to cover incidental

Table 5. Changes in the Ontario fisheries regulations for walleye in eastern Lake Ontario (Wood 1984).

Year	Regulation Change
1967	- 4.5 inch gillnet was banned west of Glenora in the Bay of Quinte, and this yardage was converted to 3 - 3.25 inches
1979	- all gillnet, other than 8 inch, was banned west of Glenora in the Bay of Quinte
1980	- 4.5 inch gillnet was banned - 75,000 lb. of walleye allocated to commercial fishery - Brighton area closed to gillnets in August because of high walleye harvest - angler possession limit changed from 6 to 4 walleye
1981	- 11,000 lb. of walleye allocated to commercial fishery
1982	- 4.5 inch gillnet was allowed
1983	- 11,000 lb. of walleye allocated to commercial fishery
1984	- 11,000 lb. of walleye allocated to commercial fishery - in June the walleye quota was set to 0

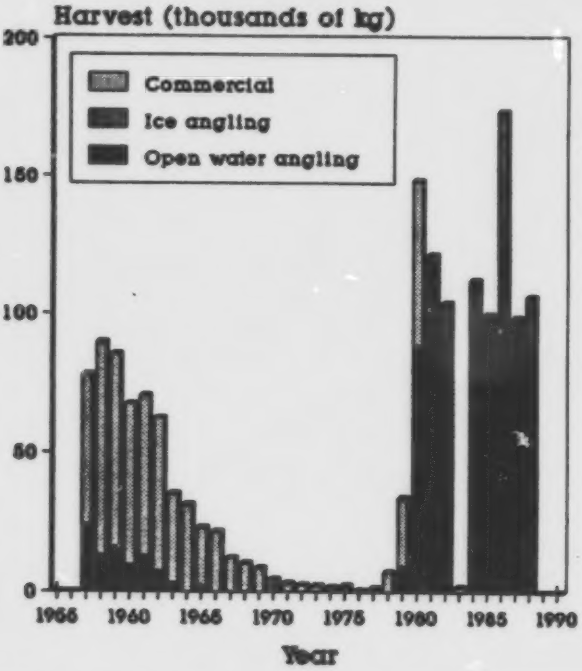

FIG. 14. Harvest of walleye by Ontario commercial and angler fisheries in Lake Ontario during 1957-1987. Angling harvest estimates are not available for all years.

catch of walleye in gear targetted towards other species, but otherwise were restricted from catching walleye. Since 1984 the walleye quotas for the commercial fishery have been set to zero, and hence, angling has become the single legal harvester of walleye. Poaching, incidental catch by commercial fishermen, and Native harvests are largely unquantified but probably represent less than 5% of the adult walleye population.

Walleye angling in eastern Lake Ontario has been restricted almost entirely to the Bay of Quinte. Anglers in the Bay of Quinte have shown a very strong preference for walleye although they sought a wider variety of species during the years of low walleye abundance. Angling effort has grown dramatically since the early 1980s (Fig. 15). The bulk of the angling harvest

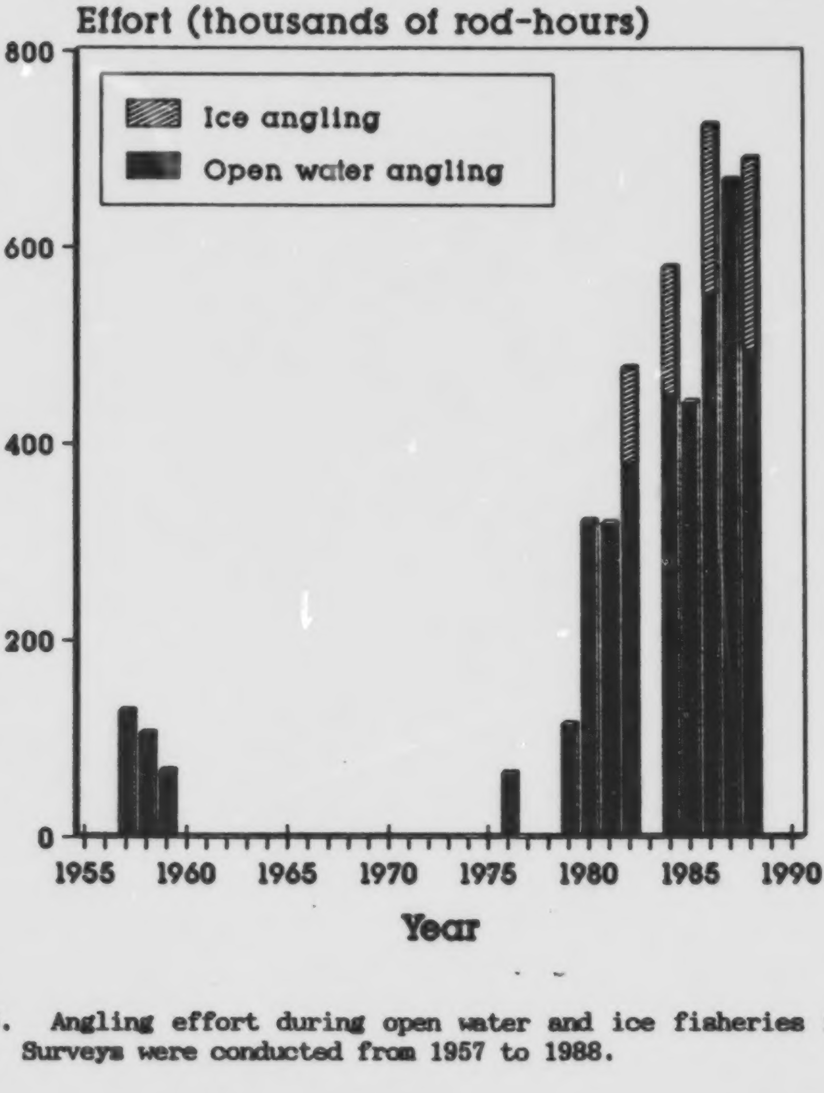

FIG. 15. Angling effort during open water and ice fisheries in the Bay of Quinte. Surveys were conducted from 1957 to 1988.

currently takes place in the open water fishery, and since 1982 has remained relatively constant near 100,000 walleye annually (Fig. 14). Prior to 1980 angling effort was restricted to the summer only (W. J. Christie, pers. comm.), but an ice fishery has since grown gradually and currently takes about 20,000 walleye annually (Fig. 14). Recent harvests-per-effort (HPE) are similar to the late 1950s (Fig. 16) and are typically in the range of 0.2 to 0.3 fish per hour. Angler catches and CPE are slightly higher because they release most of the walleye that are two years old and younger (Fig. 16). Colby et al. (1979) considered a CPE of greater than 0.3 to indicate a good walleye fishery, generally.

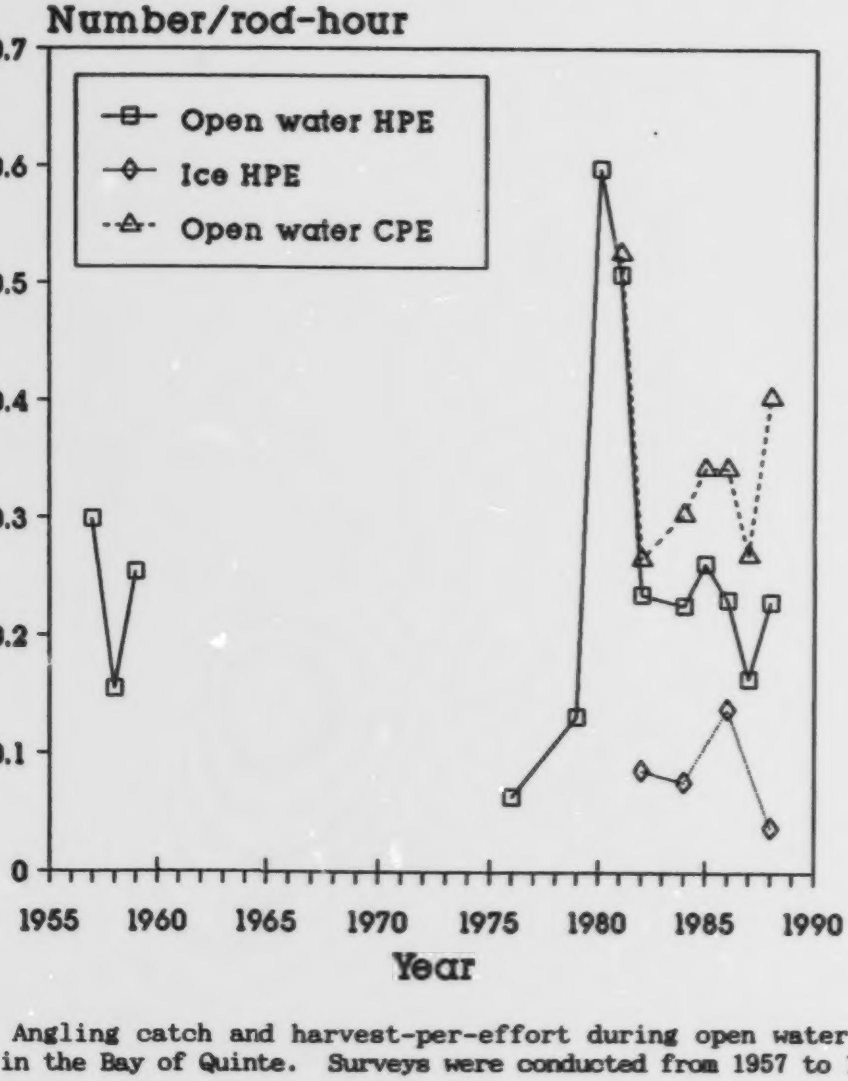

FIG. 16. Angling catch and harvest-per-effort during open water and ice fisheries in the Bay of Quinte. Surveys were conducted from 1957 to 1988.

During the open water fishery angling catch is generally highest for the 3- and 4-year-old fish (Fig. 17). Typically, about 70% of the harvest is made up of these age-classes. Two-year-old fish may be caught in large numbers but are typically released in large numbers. In 1988 we estimated that 62% of them were released. An exception occurred in 1980 when large numbers of 4-year-olds were not present and so 2-year-olds made up 89% of the harvest. During the ice fishery angling mortality is lower and more evenly distributed across all age groups. This seasonal difference in age-specific fishing mortality is likely due to habitat shifts in the older fish. Large walleye move out to the lake during summer and are not vulnerable to the fishery. However, they move back into the Bay of Quinte during fall and are caught in the ice fishery.

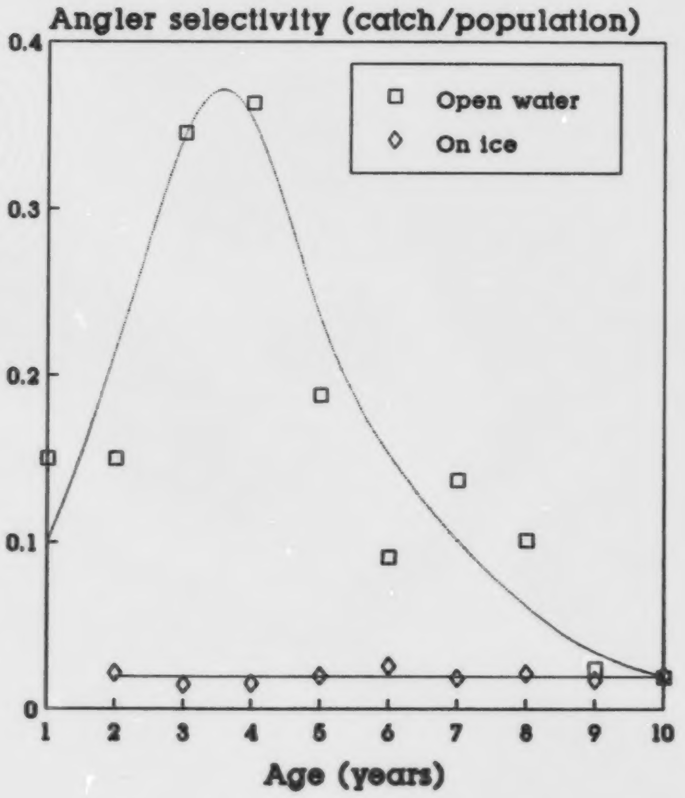

FIG. 17. Selectivity of walleye by age for open water and ice angling fisheries during 1986-1988. Curves are fit by eye.

Community Interactions

Ridgway et al. (1988) provided strong evidence for top-down control of adult alewife abundance in the upper Bay of Quinte. The abundance of adult alewife declined throughout Lake Ontario as a result of winterkill in 1978. Their abundance has since rebounded to former high levels in Lake Ontario except in the Bay of Quinte where their abundance is kept down by walleye predation (Ridgway et al. 1988). Also, these authors note that young-of-year alewife currently are higher in abundance than before the resurgence of walleye in 1977 and 1978. Ridgway et al. (1988) suggest that these higher levels of young-of-year alewife are maintained by walleye through reducing cannibalism by adult alewife. Trout-perch (*Percopsis omiscomaycus*) show a trend similar to adult alewife (Hurley 1986a) and may also be controlled by walleye predation.

White perch populations declined drastically due to winterkill in 1978 but have since only partially rebounded (Hurley 1986a). Competition with or predation by walleye and other piscivores has been suggested as a major influence in controlling white perch populations in the Bay of Quinte (Hurley and Christie 1977; Minns and Hurley 1986). The competition hypothesis seems unlikely because the growth rates of walleye are high and density dependent effects although detectable are small, and Minns and Hurley (1986) report that growth rates of white perch were much higher at walleye population peaks than during periods when walleye populations were lower. As well, diets are much different between these two species (Hurley 1986a, 1986b). Thus, predation seems to be the more likely candidate hypothesis here. Nevertheless the competition hypothesis cannot be excluded completely if this competition occurs at early critical life history stages.

The reverse effect of competition or predation by white perch in determining walleye populations is not known. With the decline in walleye after the invasion of white perch (Christie 1973) and with the occurrence of the strong 1978 year-class coinciding with the winterkill of white perch, it is tempting to postulate some strong interactions of white perch on walleye. However, the strong 1977 year-class of walleye was produced in the Bay of Quinte in the face of large white perch numbers. In addition, white perch were unable to displace walleye after invasion of West Lake (Hurley and Christie 1977) and Oneida Lake (Forney 1977).

Historically, northern pike (*Esox lucius*) were more abundant in the Bay of Quinte (Hurley and Christie 1977). Commercial harvests of northern pike far exceeded those of walleye in the early 1900s, but increases in walleye harvest during the 1920s and 1950s has coincided with decreased pike harvest (Fig. 18). Thus, it is tempting to suggest community interactions between these species. Hurley and Christie (1977) argued that the decline in northern pike population resulted from overfishing and low water levels, and moreover, that walleye benefitted from a competitive release. We suggest that the current conditions of decreased water clarity (Robinson 1986) favors walleye competitively over northern pike, and this condition may be preventing a recovery of pike to former levels. If, for whatever reason, the northern pike population in Lake Ontario recovers to historical levels then we should expect to see a decline in walleye.

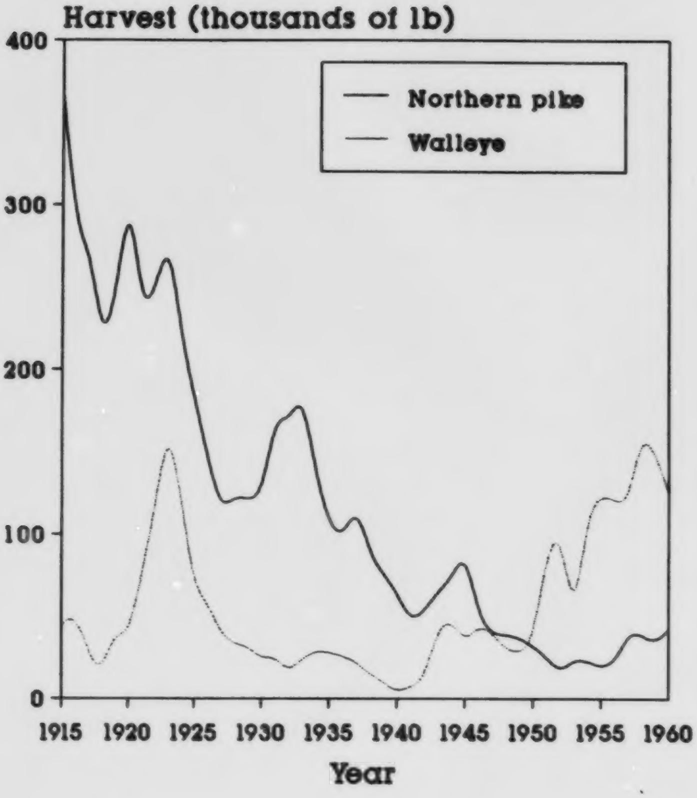

FIG. 18. The commercial harvest of northern pike and walleye in the Ontario waters of Lake Ontario. The curves represent a three year moving average.

DISCUSSION

The reasons for the resurgence of walleye populations in eastern Lake Ontario are difficult attribute to any one cause. Certainly, the resurgence corresponds in time to P control at sewage treatment plants in the Bay of Quinte (Minns et al. 1986), but, water quality as it might affect walleye (oxygen concentration and oxygen depletion rates) showed no improvements in the Bay of Quinte (Minns and Johnson 1986). However, oxygen levels in the microhabitats occupied by walleye eggs and YOY and were not measured. A winterkill of alewife and white perch occurred in 1978 may have had beneficial effects on walleye populations, but the initial resurgence began with the 1977 year-class. Therefore, community interactions could not be the main driving force of the resurgence. Perhaps as important as any other reason was the low adult population. Our analyses suggest that recruitment of the 1977 and 1978 year-classes benefitted from density-dependent factors (Fig. 9).

Walleye populations in the Ontario waters of eastern Lake Ontario appear to be fully rehabilitated. Their population appears to have stabilized near one million after declining from high levels in the early 1980s. The expansion of the population may be near an end because the available suitable habitat in the Kingston basin appears to have reached densities similar to the Bay of Quinte. Moreover, we speculate that the salmonid stocking program in Lake Ontario may bring about increased levels of competition for walleye, and therefore increased habitat specialization. Thus, the availability of less favourable habitat into which walleye might otherwise expand would be reduced.

Although the current exploitation is high, the effort also appears to have stabilized. Perhaps the reason that this population is able to withstand such high exploitation is due to the density-dependent aspects of recruitment. If this relationship is true then greater harvest might be possible at lower populations than we currently observe. The benefit of past fishing restrictions in light of such a stock recreuitment relationship are difficult to assess. However, for safe management, some further confirmation of this relationship should be undertaken before more liberal regulations might be applied.

Western Lake Ontario holds potential for more walleye beacause historically it supported a large fishery for blue pike (*S. v. glaucum*). Christie (1973) suggests that these fish were spawned in Lake Erie rather than Lake Ontario. Similarly, the current expansion of walleye in Lake Erie might lead to an overflow into Lake Ontario.

Currently, there are efforts being made through Remedial Action Plans to improve the water quality in the Bay of Quinte. If these efforts are successful then we should expect to see increased water clarity in the bay. With such a result we would predict an increase in the northern pike population and a decrease in the walleye population.

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REFERENCES

BALDWIN, N. S., R. W. SAALFELD, M. A. ROSS, AND H. J. BUETTNER. 1979. Commercial fish production in the Great Lakes 1897 - 1977. Great Lakes Fish. Comm. Tech. Rep. No. 3. 187 p.

CHRISTIE, W. J. 1973. A review of th changes in the fish species composition of Lake Ontario. Great Lakes Fish. Comm. Tech. Rep. No. 23. 65 p.

COLBY, P. J., R. E. McNICOL, AND R. A. RYDER. 1979. Synopsis of biological data on the walleye *Stizostedion v. vitreum* (Mitchell 1818). Food and Agriculture Organization of the United Nations. FAO Fisheries Synopsis No. 119. 139 p.

FORNEY, J. L. 1977. Evidence of inter- and Intraspecific competition as factors regulating walleye (*Stizostedion vitreum vitreum*) biomass in Oneida Lake, New York. J. Fish. Res. Board Can. 34: 1812-1820.

HURLEY, D. A. 1986a. Fish populations of the Bay of Quinte, Lake Ontario, before and after phosphorous control, p. 201-214. *In* C. K. Minns, D. A. Hurley, and K. H. Nicholls [ed.] Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

HURLEY, D. A. 1986b. Effect of nutrient reduction on the diet of four fish species in the Bay of quinte, Lake Ontario. p. 237-246 *In* C. K. Minns, D. A. Hurley, and K. H. Nicholls [ed.] Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

HURLEY, D. A., AND W. J. CHRISTIE. 1977. Depreciation of the warmwater fish community in the Bay of Quinte, Lake Ontario. J. Fish. Res. Board Can. 34: 1849-1860.

MINNS, C. K., AND D. A. HURLEY. 1986. Population dynamics and production of white perch, *Morone americana*, in the Bay of Quinte, Lake Ontario. p. 215-223 *In* C. K. Minns, D. A. Hurley, and K. H. Nicholls [ed.] Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

MINNS, C. K., D. A. HURLEY, AND K. H. NICHOLLS [ed.] 1986. Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

MINNS, C. K., AND M. G. JOHNSON. 1986. Temperature and oxygen conditions and oxygen depletion in the Bay of Quinte, Lake Ontario, p. 40-49. *In* C. K. Minns, D. A. Hurley, and K. H. Nicholls [ed.] Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

PAYNE, N. R. 1963. The life history of the yellow walleye, *Stizostedion vitreum vitreum* (Mitchell), in the Bay of Quinte. Master's Thesis. University of Toronto. 40 p.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

RIDGWAY, M. S., D. A. HURLEY, AND K. A. SCOTT. 1988. Temperature, predation, and the abundance of alewife in the Bay of Quinte, Lake Ontario. J. Great Lakes Res. *in press*.

ROBINSON, G. W. 1986. Water quality of the Bay of Quinte, Lake Ontario, before and after reductions of phosphorus loading, p. 50-58. *In* C. K. Minns, D. A. Hurley, and K. H. Nicholls [ed.] Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

SPANGLER, G. R., N. R. PAYNE, AND G. K. WINTERTON. 1977. Percids in the Canadian waters of Lake Huron. J. Fish. Res. Board Can. 34: 1839-1848.

WOOD, C. R. 1984. Some legislative changes for gillnet eastern Lake Ontario, Bay of Quinte. LOA Rept. 84.8, Lake Ontario Fisheries Unit, Ont. Min. Nat. Resources, Picton, Ont., KOK 2TO.

Great Lakes Fisheries Commission
Lake Ontario Committee
March 21-22, 1989
Buffalo, New York

LAKE ONTARIO WALLEYE HARVEST MANAGEMENT MODEL

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ABSTRACT

An age and size structured model was developed to simulate the walleye population and associated fisheries in eastern Lake Ontario. The model allowed evaluation of bag limits, various types of slot and size limits, season duration and quota regulations on the angling and commercial fisheries. Simulations suggested that recruitment has the major influence on the population predictions. However, the recruitment calculations were the weakest part of the model.

RECOMMENDATIONS

1. Incorporate updated recruitment model when available.

2. Perform a sensitivity analysis to determine which parameters have the greatest potential to influence the predictions.

3. Each year as new population and harvest data become available, use these data to test the model's reliability, and to calibrate its parameters.

4. When the population of one- or two-year-olds can be predicted reliably from YOY in trawls and when natural mortality estimates are reliable then discontinue mark-recapture work on yearly basis (probably after 1990 field season). However, age-specific population estimates should be made every 5 years as a test of the model's calibration.

5. A major environmental or fish community shift requires model recalibration. Routine index fishing data should be examined closely for such shifts.

INTRODUCTION

The walleye (*Stizostedion vitreum*) population and walleye angling fishery in eastern Lake Ontario (particularly in the Bay of Quinte) have stabilized (Bowlby et al. 1989). In the future we expect greater demands upon the walleye population. On experimental permits in 1989, the commercial fishery will be allowed to take a small quantity of walleye (30,000 lb.; size between 18 and 24 in. TL) in entrapment gear in Lake Ontario. The Napanee

District Fisheries Management Plan (DFMP) has projected a 35% increase in angling effort in the Bay of Quinte from 1988 to the year 2000. To maintain the quality of the existing walleye angling fishery, we anticipate the need for additional management options.

To aid managers in the evaluation of various management options we have developed a walleye harvest management model. This model has evolved out of the Ontario Ministry of Natural Resources Walleye Management Workshop in March 1988, and the framework for our model was originally developed by J. Koonce of Case Western University and M. Jones of ESSA for this Workshop.

The model allows managers to evaluate the following management options on the eastern Lake Ontario walleye population:

- bag limits
- minimum size limits
- maximum size limits
- protected slot size limits
- fishable slot size limits
- quotas
- season duration

Results include predictions of catch, harvest, fishing effort, size of fish caught and harvested, and population. Because harvest by the fisheries does not begin on a year class until it is 2 years old, and because we can predict the population of 2-year-old from young-of-the-year catches in trawls, we can make predictions with some certainty two years in advance of the fishery.

This report describes the workings of the model and provides some sample outputs.

DESCRIPTION OF MODEL

Overview

The model is an age and size structured description of the eastern Lake Ontario walleye population. The initial age structure of the population is based on Jolly-Seber population estimates (Bowlby and Mathers 1989). The initial size structure is generated from the mean and standard deviation of the estimated length at age, based on a normal distribution. This distribution contains a specified number of length categories.

Mortality is applied on either a size or age specific basis depending on the source of the mortality. Natural mortality is applied on March 31 on an age specific basis. Thus, immature fish which are not subject to spawning related mortality (for practical purposes this might include poaching which we cannot separate from natural mortality estimates) can be assigned a lower mortality rate than mature fish. Fishing mortality is applied from three sources. First, commercial fishing mortality can be assigned within specified length restrictions and for a specified quota (weight), during a specified period of the year. Second, the open water angling mortality can be assigned for a specified minimum length, maximum length, protected slot length, and bag limit during a specified period of the year. Third, the ice angling mortality can be assigned with the same restrictions as the open water angling fishery. However, these two angling fisheries differ in the age specific selectivities, the catchabilities, and the angling effort (Bowlby et al. 1989, Mathers 1989) which must also be specified. Angling effort and size restrictions must be supplied on a yearly basis for each year of the simulation.

Growth in length follows a von Bertalanffy growth function (Bowlby et al. 1989) and the parameters must be supplied to the program. The monthly growth schedule (*i.e.* the proportion of yearly growth assigned to each month) must also be supplied. Weight is generated from a length-weight regression.

Walleye ages are incremented on April 1. The number of age categories must be specified. The youngest age is 1, and all ages older than the oldest age category are grouped together with the oldest age category.

Recruitment of 1-year-olds is based on a Ricker stock recruitment model (Bowlby et al. 1989) of the number of adults in the population at the beginning of the previous year. The recruitment estimate has a log-normally distributed random error added, where this error is based on the standard deviation of the residual error of the Ricker model. Also, a minimum level of recruitment can be specified.

Because this random error is applied to the recruitment, all long term predictions present only a potential scenario rather than an accurate prediction. Running the model with different sets of random errors in the recruitment can provide some insight into the range of potential outcomes for the specified scenario. However, we can make more accurate predictions of harvest two years in advance because all harvested age classes have been previously specified under the initial conditions.

The model is written in QuickBasic. A listing of the code is in Appendix 1, and Fig. 1 is a summary flow chart. The current code in no way can be considered a final product. In particular the data input and output routines need to be customized to suit our management needs. Currently, some of the data are entered via Lotus 1-2-3 spreadsheets while other data are entered at the top of the program. Similarly, some of the output goes directly to a printer while other output goes to files structured for input to Lotus 1-2-3 spreadsheets. Greater consistency is required in the input and output.

For those familiar with the original Workshop version we have changed the model from a Type 2 to a Type 1 population (Ricker 1975:10). In so doing we have assumed all of the natural mortality occurs during the season closed to fishing. Other changes include the method for calculation of bag limits (Mathers 1989) and the addition of quota limits, fishable slot limits, and separate age specific angler selectivities for open water and ice fisheries. Also, density-dependent growth adjustments have been removed.

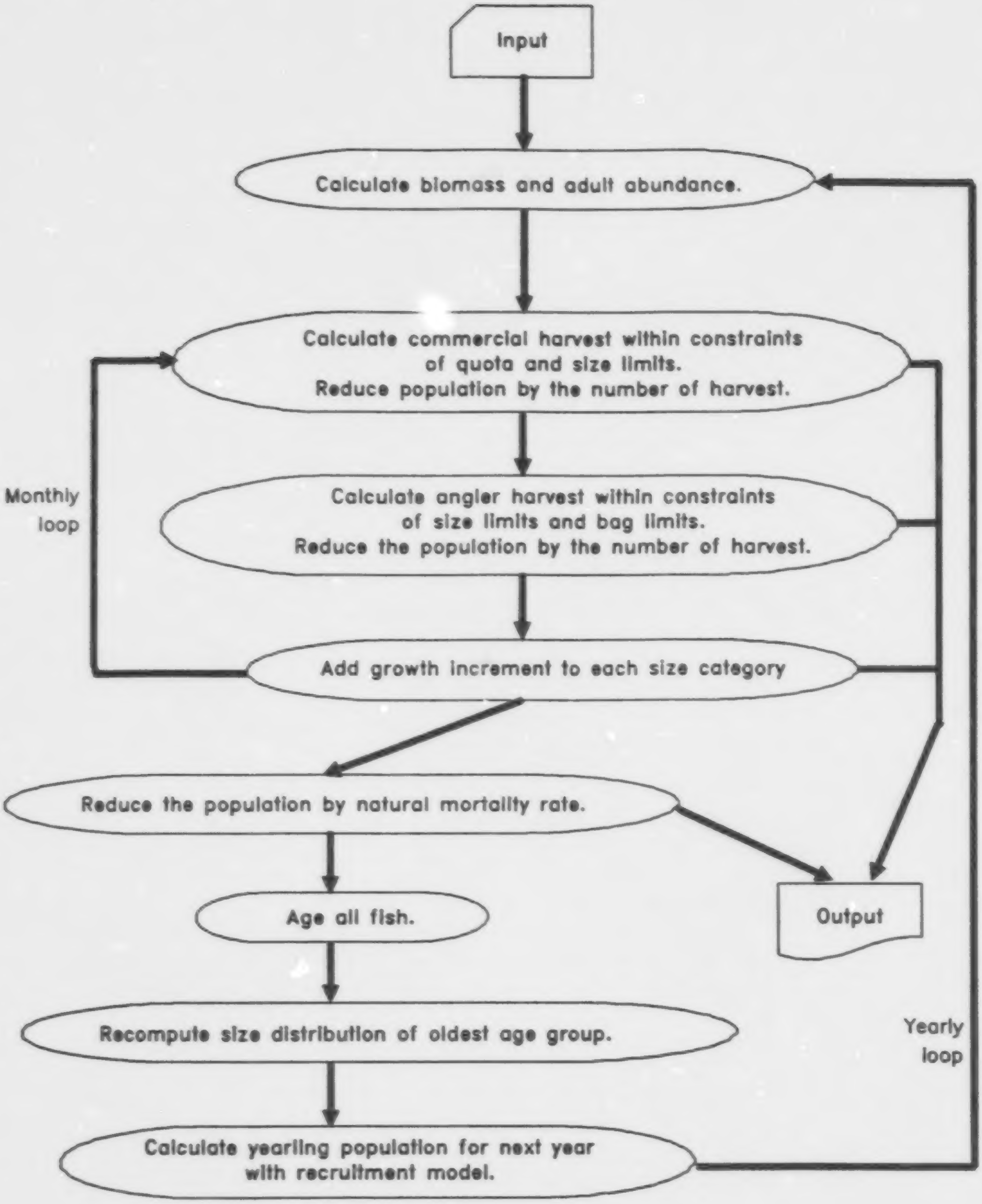
Input
Calculate biomass and adult abundance.
Calculate commercial harvest within constraints of quota and size limits. Reduce population by the number of harvest.
Calculate angler harvest within constraints of size limits and bag limits. Reduce the population by the number of harvest.
Monthly loop
Add growth increment to each size category
Reduce the population by natural mortality rate.
Output
Age all fish.
Recompute size distribution of oldest age group.
Yearly loop
Calculate yearling population for next year with recruitment model.

Fig. 1. Lake Ontario walleye harvest management model.

Data input

The following is a list of the most important data variables that must be input to the model and the description of the variable:

Variable	Description
ny	Number of years to simulate
nz	Number of length categories within an age class
nm	Number of "months" in a year
nage	Number of age categories
qmin	Minimum proportion of released fish killed by hooking
minyearlings	Minimum recruitment
maxcomlen	Upper commercial slot length
mincomlen	Lower commercial slot length
quota	Commercial quota in grams
cadprh	Angler-day/rod-hr conversion
rseed	Random number generator seed
lwa, lwa	Length-weight regression coefficients (power function)
sra, srb	Stock recruitment model coefficient (Ricker model)
sre	Stock recruitment model standard deviation
linf	Von Bertalanfy L-infinity growth function parameter
sdl	Standard deviation of length
t0, kgrowth	Von Bertalanfy growth function parameters
pag(I)	Proportion of yearly growth in month I
mlmin	Minimum length for female maturity
qrecow	Catchability for open water angling fishery
qrecice	Catchability for ice angling fishery
qsize	Minimum size caught
natmorti	Natural mortality of immature fish
natmortm	Natural mortality of mature fish
qss(1, I)	Open water angling selectivity for age I
qss(2, I)	Ice angling selectivity for age I
xbar(I)	Mean length at age I
std(I)	Standard deviation of mean length at age I
n(I, J)	Population of age I in length category J
length(I, J)	Length of age I in length category J
effort(K, L)	Angling effort (rod-hours) in month L and year K
totalbl(I)	Angling bag limit
trophbl(I)	Upper slot angling bag limit - currently not used
lowersl(I)	Minimum protected angling slot length
uppersl(I)	Maximum protected angling slot length

Data Output

The following is a list of some of the output that the model is capable of providing:

- population number and weight by age at the beginning of each year
- angler catch and harvest in number and weight by age for each year
- commercial harvest in number and weight by age for each year
- average weight of fish caught and harvested in each fishery
- catch per effort and harvest per effort
- catch of trophy (size greater than protected slot)

EXAMPLE OUTPUT

The model was run for 20 years starting at 1989. The following outputs were based on a 35% increase in angling effort by the year 2000 to conform to the projections of the Napanee DFMP. Effort continued to rise by the same amount yearly throughout each simulation. All other parameters were held constant, through time and regulations were kept at the 1989 conditions. Three simulations were made and these differed only in the series of random numbers associated with the recruitment of 1-year-olds.

The selected output shows the recruitment of 1-year-olds, the population of 1-year-olds and older, the angling catch per effort (CPE) for combined open water and ice fisheries, and the average length of angler harvested walleye (Figure 2). These simulations suggest that the eastern Lake Ontario walleye population would be quite stable under conditions of increasing effort. The population fluctuates quite a bit but in general follows the recruitment. Increased effort and catch can decrease the population in years of poor recruitment, but density-dependent recruitment rates tend to prevent the population from crashing. The angling CPE mirrors the population, but with a two year lag. This lag corresponds to the time from when a year class is recruited to the population (1 year old) and when it completely enters the fishery (3 years old). The trend in average size tends to increase as the CPE decreases. This reflects "fishing up" of strong year classes.

Note that as stated above the first two years of the simulation (1989, and 1990) do not differ in the catch results, because the randomly generated year classes have not yet entered the fishery. Therefore, predictions for these two years are should be fairly accurate. Predictions for later years must be examined with several simulations to determine the general stability of the predictions.

One of the next steps should be to perform a sensitivity analysis to determine which parameters have the greatest potential to influence the predictions. The key to the stability of these predictions appears to lie with recruitment. The recruitment calculations are the weakest part of the model, and we have suggested elsewhere that further recruitment modeling is necessary (Bowlby et al. 1989). The walleye harvest model should incorporate an updated recruitment model when available. As well, when new population and harvest data become available, these data should be used as a test of the reliability of the model and to calibrate the model parameters. When the

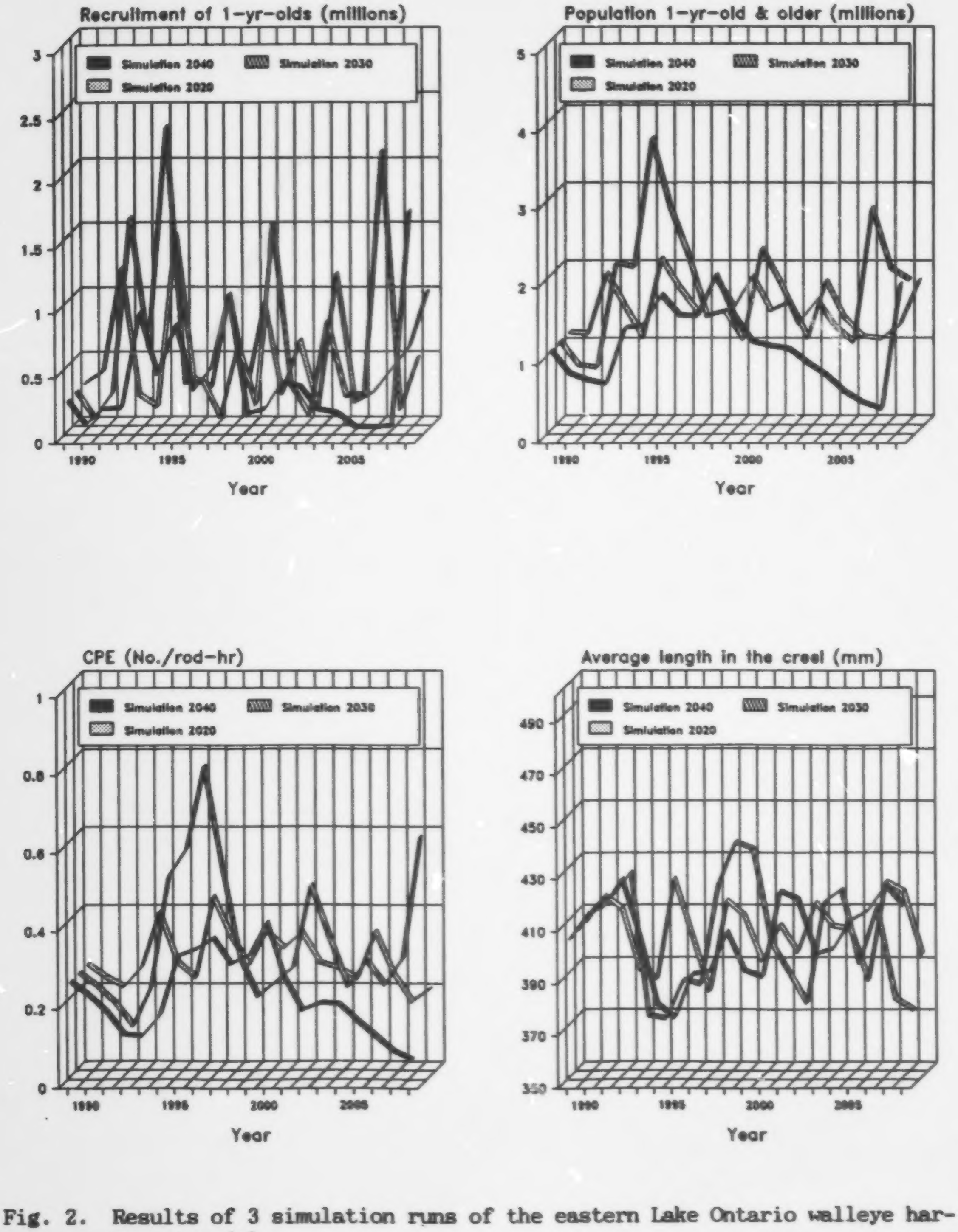

Fig. 2. Results of 3 simulation runs of the eastern Lake Ontario walleye harvest management model.

population of one- or two-year-olds can be predicted reliably from YOY in trawls and when natural mortality estimates are reliable then mark-recapture work on yearly basis should be discontinued (probably after 1990 field season). However, age-specific population estimates should be made every 5 years as a test of the model's calibration. Note that a major environmental shift (*e.g.* climate warming) or fish community shift (*e.g.* increase in northern pike) would require the model to be recalibrated. Routine index fishing data should be examined closely for such shifts.

ACKNOWLEDGMENTS

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REFERENCES

BOWLBY, J. N., AND A. MATHERS. 1989. Walleye populations in eastern Lake Ontario and the Bay of Quinte, 1988. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 8. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J. N., A. MATHERS, AND D. A. HURLEY. 1989. The status of walleye in the Canadian waters of Lake Ontario. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 9. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

MATHERS, A. 1989. Bay of Quinte angling surveys, 1988. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 2. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada. Bulletin 191:1-382.

APPENDIX 1. Listing of QuickBasic code for Lake Ontario walleye management model.

```
DECLARE SUB prtout ()
DECLARE SUB comcatch ()
DECLARE SUB stdnorm (z!)
DECLARE SUB calcyear ()
DECLARE SUB baglim ()
DIM n(12, 10), xbar(12), std(12), length(12, 10), effort(20, 12), qss(2, 12)
DIM lowersl(20),uppersl(20),stl(20), wk(12), angr(12), pag(12), weight(12, 10)
DIM harvnumb(12), harvbiom(12), numb(12), biom(12), trophbl(20), totalbl(20)
DEFINT I-J

starttime = TIMER               'FOR TIME TO RUN PROGRAM

REM general variables
xy = -1
ny = 20                         'NUMBER OF YEARS
nz = 10                         'NUMBER OF LENGTH CATEGORIES WITHIN AGE CLASS
nm = 6                          'NUMBER OF MONTHS
nmm1 = nm - 1
nmm2 = nm - 2
nage = 12                       'NUMBER OF AGE CATEGORIES
nageml = nage - 1
zl = -2!                        'FOR CALC. LENGTH DIST. FOR AN AGE CLASS
zint = -2 * zl / nz             'FOR CALC. LENGTH DIST. FOR AN AGE CLASS
qmin = .05                      'MINIMUM FISHING MORTALITY DUE TO HOOKING
fishstock = 0                   'THE BASIS FOR MAKING SOME ORIENTAL SOUPS
minyearlings = 100000           'minimum recruitment
maxcomlen = 579            'UPPER COMMERCIAL SLOT LIMIT - 531 mm fl = 22 in tl
                           '  "       "       "    "   - 555 mm fl = 23 in tl
                           '  "       "       "    "   - 579 mm fl = 24 in tl
mincomlen = 434            'LOWER COMMERCIAL SLOT LIMIT - 434 mm fl = 18 in tl
quota = 30000 / 2.2 * 1000   'COMMERCIAL QUOTA IN LB to GRAMS

OPEN "c:\slot\den.prn" FOR OUTPUT AS #2
OPEN "c:\slot\size.prn" FOR OUTPUT AS #3
OPEN "c:\slot\varsiz.prn" FOR OUTPUT AS #4
OPEN "c:\slot\gen.prn" FOR OUTPUT AS #5

REM read all initial values from a Lotus print file
OPEN "c:\slot\wdat.prn" FOR INPUT AS #1
INPUT #1, cadprh, rseed         'ANGLER-DAY/ROD-HR,RANDOM SEED
RANDOMIZE rseed
INPUT #1, lwa, lwb              'LENGTH-WEIGHT COEFFICIENTS
INPUT #1, sra, srb, sre         'STOCK-RECRUITMENT COEFFICIENTS & STANDARD DEV.
INPUT #1, linf, sdl             'BERTALANFY L-infinity, standard dev. of length
INPUT #1, t0, kgrowth           'BERTALANFY GROWTH PARAMETERS
FOR I = 1 TO nm
        INPUT #1, pag(I)        'MONTHLY PROPORTIONAL GROWTH
NEXT I
INPUT #1, mlmin                 'MINIMUM LENGTH FOR FEMALE MATURITY
INPUT #1, qrecow, qrecice, qsize, natmorti, natmortm 'RELATIVE CATCHABILITIES:
        'OPEN WATER,ICE;MINIMUM SIZE OF CATCH,NATURAL MORTALITY(ACTUAL):
        'IMMATURE,MATURE
FOR I = 1 TO nage
        INPUT #1, qss(1, I)       'AGE-SPECIFIC OPEN WATER FISHING MORTALITY
        qss(1, I) = qss(1, I) * qrecow  'AGE-SPECIFIC OPEN WATER CATCHABILITY
NEXT I
FOR I = 1 TO nage
        INPUT #1, qss(2, I)       'AGE-SPECIFIC ICE FISHING MORTALITY
        qss(2, I) = qss(2, I) * qrecice  'AGE-SPECIFIC ICE CATCHABILITY
NEXT I
REM read initial values from file
FOR iage = 1 TO nage
        INPUT #1, nt, xbar(iage), std(iage) 'POPULATION,MEAN LENGTH, STD. DEV
                                                 'OF LENGTH
        FOR J = 1 TO nz            'FIT LENGTH DISTRIBUTION TO NORMAL CURVE
                z = zl + zint * J
                n(iage, J) = nt * zint * .4 * EXP(-(z ^ 2) / 2) / .95415
                length(iage, J) = xbar(iage) + z * std(iage)
        NEXT J
NEXT iage
REM read May to February Fishing Effort (Rod-hrs/"month") for NY years
FOR I = 1 TO ny
        FOR J = 1 TO nmm1
                INPUT #1, effort(I, J)
        NEXT J
NEXT I
REM read bag limit and slot limit data for NY years
FOR I = 1 TO ny
        INPUT #1, totalbl(I), trophbl(I), lowersl(I), uppersl(I)
NEXT I

REM Calculate annual growth increment
lenyrlngs = linf * (1 - EXP(kgrowth * (1 - t0)))
FOR I = 1 TO nage
        leng = linf * (1 - EXP(kgrowth * (I - t0)))
        leng2 = linf * (1 - EXP(kgrowth * (I - t0 + 1)))
        angr(I) = leng2 - leng
NEXT I

REM Annual Time Loop ********************************************************

FOR iy = 1 TO ny
 xy = iy
 PRINT "start of year "; iy; "elapsed Time: "; TIMER - starttime
 starttime = TIMER

 REM Calculate biomass and adult abundance
 totbiom = 0
 adults = 0
 FOR I = 1 TO nage
         harvnumb(I) = 0      'SET AGE-SPECIFIC ANGLER HARVEST TO ZERO
        harvbiom(I) = 0       'SET AGE-SPECIFIC ANGLER HARVEST (BIOM) TO ZERO
        biom(I) = 0           'SET AGE-SPECIFIC BIOMASS TO ZERO
        numb(I) = 0           'SET AGE-SPECIFIC POPULATION TO ZERO
        FOR J = 1 TO nz
                w = n(I, J) * lwa * length(I, J) ^ lwb
                biom(I) = biom(I) + w
                numb(I) = numb(I) + n(I, J)
                totbiom = totbiom + w
                IF length(I, J) > mlmin THEN adults = adults + n(I, J)
        NEXT J
NEXT I
asly = log(adults)*2.302585   'SCALE FOR RECRUITMENT MODEL

REM print initial population parameters
LPRINT
LPRINT "WALLEYE POPULATION SIMULATION"
LPRINT "INITIAL CONDITIONS FOR YEAR", iy
LPRINT
LPRINT "AGE", "NUMBER", "WEIGHT"
LPRINT "", "", "(lb)"
FOR I = 1 TO nage
      LPRINT I, numb(I), biom(I) / 1000 * 2.2
NEXT I
LPRINT
LPRINT

REM initialize harvest terms
totcatch = 0
trophden = 0
lbarcatch = 0
lbartroph = 0
totfishexp = 0
toteffort = 0
fishery = 1                     '1 = open water; 2 = ice

REM begin monthly loop
FOR im = 1 TO nmml
 IF im = 2 AND iy > 1 THEN CALL comcatch 'set 2 for end of June
 IF im = nmml THEN fishery = 2
 REM calculate mortality of each age group
 REM check bag limit constraints
 REM assign slot limit hooking mortality
 FOR I = 1 TO nage
     FOR J = 1 TO nz
       q = 0
       IF length(I, J) > qsize THEN
         IF (length(I, J) > lowersl(iy) AND length(I, J) <= uppersl(iy)) THEN
                 q = qmin * qss(fishery, I)
                 ELSE
                        q = qss(fishery, I)
          END IF
       END IF
```

```
        totz = effort(iy, im) * q / nm 'TYPE I FISHERY - FISHING MORTALITY
                                        'ONLY
        REM harvest calculation
        harvest = q * effort(iy, im) * n(I, J)

        CALL baglim

        harvnumb(I) = harvnumb(I) + harvest
        w = harvest * lwa * length(I, J) ^ lwb
        harvbiom(I) = harvbiom(I) + w
        totcatch = totcatch + harvest
totfishexp=totfishexp-(length(I,J)>qsize)*qss(fishery,I)*effort(iy,im)*n(I,J)
        IF length(I, J) > uppersl(iy) THEN
               trophden = trophden + harvest
               lbartroph = harvest * length(I, J) + lbartroph
        END IF
        lbarcatch = lbarcatch + harvest * length(I, J)

        REM mortality
        n(I, J) = n(I, J) * EXP(-totz)

        REM grow each size group
        length(I, J) = length(I, J) + (angr(I) * pag(im))
      NEXT J
  NEXT I
  toteffort = toteffort + effort(iy, im)
 NEXT im
 lbartroph = lbartroph / (trophden + .000001)
 lbarcatch = lbarcatch / (totcatch + .000001)

 REM print angler harvest
 LPRINT
 LPRINT
 LPRINT "WALLEYE ANGLER HARVEST RESULTS FOR YEAR", iy
 LPRINT
 LPRINT "AGE", "NUMBER", "WEIGHT"
 LPRINT "", "", "(lb)"

 FOR I = 1 TO nage
        LPRINT I, harvnumb(I), harvbiom(I) / 1000 * 2.2
 NEXT I

 REM Calculate natural mortality
 FOR iage = 1 TO nage
        FOR J = 1 TO nz
            IF  length(iage, J) < mlmin THEN
                  n(iage, J) = n(iage, J) * (1 - natmorti)
                  ELSE n(iage, J) = n(iage, J) * (1 - natmortm)
        NEXT J
 NEXT iage
```

```
CALL prtout
REM age all fish and recompute size distribution of oldest age group
sxnage = 0
sx2nage = 0
sxnageml = 0
sx2nageml = 0
nnage = 0
nnageml = 0
FOR J = 1 TO nz
       sxnage = length(nage, J) * n(nage, J) + sxnage
       sx2nage = length(nage, J) ^ 2 * n(nage, J) + sx2nage
       sxnageml = length(nageml, J) * n(nageml, J) + sxnageml
       sx2nageml = length(nageml, J) ^ 2 * n(nageml, J) + sx2nageml
       nnage = nnage + n(nage, J)
       nnageml = nnageml + n(nageml, J)
NEXT J
   xbnage = sxnage / nnage
   IF nnageml = 0 THEN nnageml = 1
   xbnageml = sxnageml / nnageml
   vnage = (sx2nage - xbnage * xbnage * nnage) / (nnage)
   vnageml = (sx2nageml - xbnageml * xbnageml * nnageml) / (nnageml)
   xbnage = (xbnage + xbnageml) / 2
   vnage = vnage + vnageml
   IF vnage < 0 THEN vnage = 0
sdnage = SQR(vnage)
   nnage = nnage + nnageml

REM recalculate size distribution of age nage

FOR I = 1 TO nz
        z = zl + zint * I
        n(nage, I) = .4 * EXP(-z ^ 2 / 2) * nnage * zint / .95415
        length(nage, I) = xbnage + z * sdnage
NEXT I

REM Age year classes less than nage

FOR I = nageml TO 2 STEP -1
       FOR J = 1 TO nz
               n(I, J) = n(I - 1, J)
               length(I, J) = length(I - 1, J)
       NEXT J
       wk(I) = wk(I - 1)
NEXT I

REM calculate yearling production
CALL stdnorm(z)
CALL calcyear

NEXT iy
REM End of Annual Time Loop ***********************************************
END
```

```
DEFSNG I-J
SUB baglim

SHARED harvest, totalbl(), xy

SELECT CASE totalbl(xy)
        CASE 1
              harvest = harvest * .5215
        CASE 2
              harvest = harvest * .7983
        CASE 3
              harvest = harvest * .9062
        CASE 4
              harvest = harvest * 1
        CASE 5
              harvest = harvest * 1.0602
        CASE 6
              harvest = harvest * 1.0994
        CASE 7
              harvest = harvest * 1.1268
        CASE 8
              harvest = harvest * 1.1472
        CASE 9
              harvest = harvest * 1.1603
        CASE 10
              harvest = harvest * 1.1691
        CASE ELSE
              PRINT 'BAG LIMIT RANGE EXCEEDED'
              STOP

        END SELECT

END SUB     '************************************************************

SUB calcyear
DEFINT I
 SHARED nyearlings, asly, sra, srb, sre, adults, z
 SHARED nz, zl, zint, minyearlings, natmorti
 SHARED n(), length(), sdl, lenyrlngs

 log2yrold = asly * sra * EXP(-srb * asly)      'Ricker model
 log2yrold = log2yrold + z * sre                'add random number

 nyearlings = EXP(log2yrold * 2.302585) / (1 - natmorti)
 IF nyearlings < 100000 THEN nyearlings = minyearlings

 asly = LOG(adults) / 2.302585

 REM set up size frequencies of yearlings

 FOR I = 1 TO nz
```

```
        z = zl + zint * I
        n(1, I) = .4 * EXP(-z ^ 2 / 2) * nyearlings * zint / .95415
        length(1, I) = z * sdl + lenyrlngs

 NEXT I

END SUB     '************************************************************

DEFSNG I
SUB comcatch
SHARED lwa, lwb, maxcomlen, mincomlen, nage,nz,n(),length(),weight(),xy, quota
DEFINT I-J

LPRINT
LPRINT
LPRINT "WALLEYE COMMERCIAL HARVEST RESULTS FOR YEAR ", xy
LPRINT "MINIMUM SLOT TOTAL LENGTH (in) IS ", mincomlen / .95 * .03937
LPRINT "MAXIMUM SLOT TOTAL LENGTH (in) IS ", maxcomlen / .95 * .03937
LPRINT
LPRINT "BEFORE HARVEST"
comwtpottot = 0
comdenpottot = 0
wttot = 0
dentot = 0
LPRINT "AGE", "NUMBER", "WEIGHT", "NUMBER", "WEIGHT"
LPRINT "", "", "(lb)", "AVAILABLE", "AVAILABLE"
FOR I = 1 TO nage
        wt = 0
        comwtpot = 0
        comdenpot = 0
        den = 0
        FOR J = 1 TO nz
                weight(I, J) = lwa * length(I, J) ^ lwb
               IF length(I, J) >= mincomlen AND length(I, J) <= maxcomlen THEN
                        comwtpot = comwtpot + weight(I, J) * n(I, J)
                        comdenpot = comdenpot + n(I, J)
                END IF
                wt = wt + weight(I, J) * n(I, J)
                den = den + n(I, J)
        NEXT J
        wtout = wt * 2.2 / 1000
        comwtpotout = comwtpot * 2.2 / 1000
        LPRINT I, den, wtout, comdenpot, comwtpotout
        comdenpottot = comdenpottot + comdenpot
        comwtpottot = comwtpottot + comwtpot
        dentot = dentot + den
        wttot = wttot + wt
NEXT I
wttotout = wttot * 2.2 / 1000
comwtpottotout = comwtpottot * 2.2 / 1000
LPRINT "TOTAL", dentot, wttotout, comdenpottot, comwtpottotout
LPRINT
```

```
commort = quota / comwtpottot  'COMMERCIAL MORTALITY WITHIN SLOT
PRINT commort

LPRINT "AFTER HARVEST"
comwtpottot = 0
comdenpottot = 0
wttot = 0
dentot = 0
LPRINT "AGE", "NUMBER", "WEIGHT", "NUMBER", "WEIGHT"
LPRINT "", "REMAINING", "REMAINING", "HARVESTED", "HARVESTED"
FOR I = 1 TO nage
        wt = 0
        comwtpot = 0
        comdenpot = 0
        den = 0
        FOR J = 1 TO nz
               IF length(I, J) >= mincomlen AND length(I, J) <= maxcomlen THEN
                        ncommort = n(I, J) * commort
                        comwtpot = comwtpot + weight(I, J) * ncommort
                        comdenpot = comdenpot + ncommort
                        n(I, J) = n(I, J) - ncommort
                END IF
                wt = wt + weight(I, J) * n(I, J)
                den = den + n(I, J)
        NEXT J
        wtout = wt * 2.2 / 1000
        comwtpotout = comwtpot * 2.2 / 1000
        LPRINT I, den, wtout, comdenpot, comwtpotout
        comdenpottot = comdenpottot + comdenpot
        comwtpottot = comwtpottot + comwtpot
        dentot = dentot + den
        wttot = wttot + wt
NEXT I
wttotout = wttot * 2.2 / 1000
comwtpottotout = comwtpottot * 2.2 / 1000
LPRINT "TOTAL", dentot, wttotout, comdenpottot, comwtpottotout

END SUB     '***********************************************************

DEFSNG I-J
SUB prtout
DIM den(12), lbar(12), std(12)
DEFINT I
SHARED n(), length(), qsize, iy, lowersl(),uppersl(),lwa,lwb, qss(),totfishexp
SHARED toteffort
SHARED totcatch, totbiom, trophden, lbarcatch, lbartroph, lakearea, nage, nz
psdsl = 250
psdsu = 380

REM print age structure
npsdsl = 0
npsdsu = 0
```

```
fishstock = 0
FOR I = 1 TO nage
        num = 0
        sx = 0
        sx2 = 0
        FOR J = 1 TO nz
                qfs = 0
                IF length(I, J) > qsize THEN qfs = 1
                fishstock = fishstock + qfs * n(I, J)
                npsdsl = npsdsl - (length(I, J) > psdsl) * n(I, J)
                npsdsu = npsdsu - (length(I, J) > psdsu) * n(I, J)
                num = num + n(I, J)
                nwt = n(I, J) * length(I, J)
                sx = sx + nwt
                sx2 = sx2 + n(I, J) * length(I, J) ^ 2
        NEXT J
        IF num = 0 THEN num = 1
        den(I) = num
        lbar(I) = sx / num
        std(I) = SQR((sx2 - sx * sx / num) / (num))
NEXT I
cpue = totfishexp / (toteffort + .000001)
wbar = lwa * lbarcatch ^ lwb
hpue = totcatch / (toteffort + .000001)
hpuew = totcatch * wbar / (toteffort + .000001)
yield = totcatch * wbar
psd = npsdsu / (npsdsl + .000001) * 100
FOR I = 1 TO nage
        PRINT #2, den(I); " ";
NEXT I
PRINT #2,
FOR I = 1 TO nage
        PRINT #3, lbar(I); " ";
NEXT I
PRINT #3,
FOR I = 1 TO nage
        PRINT #4, std(I); " ";
NEXT I
PRINT #4,
PRINT #5, totcatch; " "; totbiom / 1000; " "; trophden; " "; lbarcatch; " ";
      lbartroph; " "; fishstock;
PRINT #5, yield / 1000; " "; totfishexp; " "; psd; " "; cpue; " "; hpue; " ";
      hpuew / 1000
END SUB     '***********************************************************

DEFSNG I
SUB stdnorm (z)
        r = 2 * RND - 1
        z = LOG((1 + r) / (1 - r)) / 1.82
END SUB
```

Great Lakes Fishery Commission
Lake Ontario Committee Meeting
March 21-22, 1989
Buffalo, New York

INDEX GILLNETTING PROJECT, 1988

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ABSTRACT

Depth stratified index netting was conducted at transects in the Kingston Basin (Melville Shoal, Grape Island, and Flatt Point) and the Central Basin (Rocky Point, Wellington, and Presqu'ile) of Lake Ontario. Catches of warmwater fish species were highest at Melville Shoal and Grape Island. Presqu'ile and Wellington transects had the highest catches of coldwater fish species. Catches of alewife and yellow perch in the Kingston basin have declined from 1986 levels. Catch rates and growth rates of yellow perch in the Brighton area suggest past over exploitation.

RECOMMENDATIONS

1. Maintain current design of index gillnetting program.
2. Harvest of yellow perch in the Brighton area should be reduced from past levels.

INTRODUCTION

During 1986, the Lake Ontario Fisheries Assessment Unit instituted an index gillnetting program in the Kingston basin of Lake Ontario (Malone et al. 1986). This program replaced the yellow perch index program which was run in the Kingston basin from 1976 to 1985. The new program allowed investigation of the variability in catches of warmwater fish species across depth and spatial strata. During 1988 the project was extended to include three new sites in the central basin of Lake Ontario. This report presents a summary of the 1988 catch and a comparison of these data to previous catches.

METHODS

One hundred and eleven gillnet lifts were conducted between July 22, 1988 and August 21, 1988. Gillnets were lifted three times at the traditional location at Middle Grounds (near Brighton). Fifty-four lifts were conducted at the index transects established in 1986 (Flatt Point, Grape Island, and Melville Shoal) and fifty-four lifts were conducted at new transects established during 1988 (Rocky Point, Wellington, and Presqu'ile, Fig. 1). Gillnets were set overnight (set mid afternoon, lifted mid morning) at six depths along each of the transects. The sampling was repeated three times at each transect on a rotating basis. Gillnets were set parallel to the depth contours at approximately the midpoint of each of the following strata:

1) 0 to 5 m
2) 5 to 10 m
3) 10 to 15 m
4) 15 to 20 m
5) 20 to 25 m
6) 25 to 30 m

Gillnets used were the Glenora Fisheries Station standard lake gillnets which consist of eight panels (stretched mesh sizes): 5 yards of 1.5" mesh, 25 yards of 2" mesh, and 50 yards each of 2.5", 3", 4.5", and 5" meshes. Shorter lengths of the 1.5" and 2" meshes were used to avoid large catches of alewife.

The following data were recorded for each lift:

1) all fish were counted by species for each mesh size

2) aggregate weight by species for each mesh size

3) fork length tally (in 1 cm intervals) by species for each mesh size to a maximum of 100 fish

4) for each species, at each netting location, the first five fish (15 yellow perch) in each 1 cm fork length size-class were biosampled regardless of the water depth and mesh size of capture. Biosampling included recording fork length, weight, scale sample, sex, clips, marks, and tags. Also, coded wire tags were removed from the heads of lake trout with an adipose clip.

All 1988 data collection for this project (except the three gillnet lifts at Middle Grounds) were conducted by KJB Biotech (R. R. # 8, Picton, Ontario, K0K 2T0) under contract with the Ontario Ministry of Natural Resources.

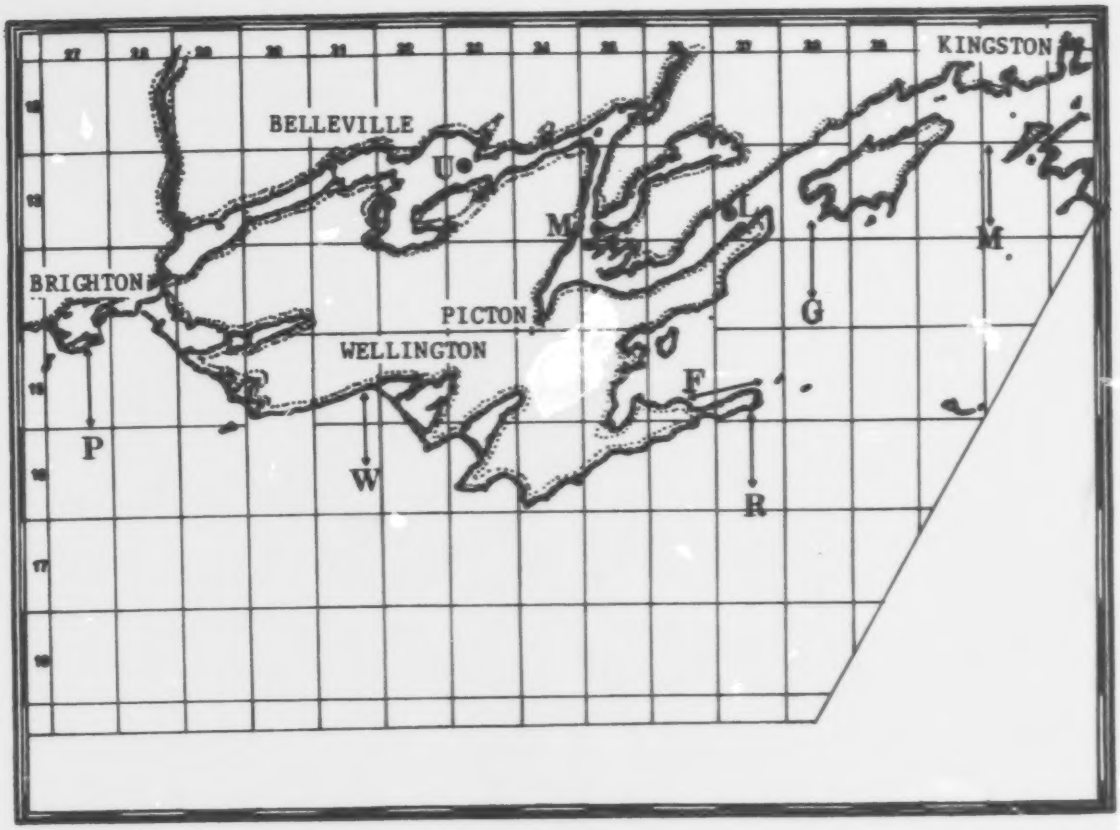

Figure 1. LOFU 1988 index gillnetting locations in eastern Lake Ontario. Transects were located at Presqu'ile Point (P), Wellington (W), Rocky Point (R), Flatt Point (F), Grape Island (G), and Melville Shoal (M). Research index stations were located at upper (U), middle (M), and lower (L) Bay of Quinte.

Analysis

Catches from each gillnet panel (mesh size) were extrapolated to 100 meters and then added by species to produce a standardized catch for each gillnet lift (ie. 800m of net). These data were transformed ($\ln(x + 1)$) and analysis of variance (SAS GLM procedure) were performed to compare the catch data for individual species by year and location. Differences between means were compared using least-square means (LSMEANS option of GLM). The least-square means (referred to as 'adjusted means' from here on) represent values which are adjusted for unequal variation in water temperature to allow easy comparison.

Water temperature recorded at the gillnet was used as a covariate to the CUE where appropriate. Year, area, depth and their first order interaction terms were all included in a preliminary analysis. The results of the preliminary analysis were examined and insignificant sources of variation were removed from the ANOVA model before the final analysis was performed. Type III sums of squares were used in all analyses. All statistical tests used the p = 0.05 significance level.

RESULTS AND DISCUSSION

General Characteristics of the 1988 Catch

Of the thirty-three species of fish that were captured during the 1988 program, the catches of some tended to be positively correlated with water temperature ('warmwater' species), others were negatively correlated with water temperature ('coldwater' species), while the remainder were not correlated with water temperature (Table 1). Generally, catches of warmwater fish species such as white perch, rock bass, smallmouth bass, yellow perch, and walleye, tended to be highest at the Grape Island and Melville Shoal transects (Table 1). Catches of coldwater species such as alewife, chinook salmon, lake trout, and lake herring tended to be highest at Presqu'ile and Wellington. Rocky Point and Flatt Point generally had moderate catches of warm and coldwater species. Rocky Point was unique in the total absence of yellow perch, a species which was abundant at all other locations, and the presence of the lake chub, which was not present at any other transect.

Warmwater species tended to be caught at the warmer transects and coldwater species tended to be caught at colder transects. Even though the transects were fished at identical depths there was a significant difference in the water temperatures observed at the different areas (analysis of covariance, F = 4.34, p = 0.0016). The water temperatures at Melville Shoal were significantly higher than at all other locations. The temperature at Grape Island had the second highest mean and was significantly different than Presqu'ile but was not different from Wellington (Table 2).

Comparison of 1986 to 1988 Catches in the Kingston Basin

In the Kingston basin catches of alewife during the 1988 and 1987 programs were significantly lower than during 1986 (Table 3). The size of the alewife caught increased through time at Flatt Point and Melville Shoal (Table 4).

The 1988 catch of lake whitefish increased significantly from 1986 and 1987. This increase could be due to the increase in population size of the Bay of Quinte whitefish stock (Bowlby 1988). In general, the 1988 catch of walleye was not significantly different from previous years. However, when catches for the transects were examined individually the 1988 catch of walleye at Melville Shoal was significantly greater (F = 3.93, p = 0.0285) than during 1987 and 1986. The increase in the walleye catch at Melville Shoal may be due to high water temperatures this year.

Table 1. Mean catch for the six transect locations in the 1988 Index Gillnetting Program in eastern Lake Ontario. CUE's presented are the mean for the six depths at each transect ('.' indicates no fish were caught). Means for a species with the same letter at different locations are not significantly different. The relationship between the CUE data and water temperature at the gillnets is also presented: '+' indicates a significant positive relationship, '-' indicates a significant negative relationship, '.' indicates no significant relationship.

Species	Temperature Relationship	Presqu'ile	Wellington	Rocky Pt.	Flatt Pt.	Grape Is.	Melville Sh.
Longnose Gar *(Lepisosteus osseus)*	.	.	.	.	.	.	0.24
Bowfin *(Amia clava)*	.	.	.	.	0.12	.	.
Alewife *(Alosa pseudoharengus)*	-	349.61A	1297.09A	466.80B,C	279.86B,C	185.19C	117.12D
Gizzard Shad *(Dorosoma cepedianum)*	+	1.46	0.85	5.07	0.24	1.46	0.73
Coho Salmon *(Onchorhynchus kisutch)*	.	0.97	0.61	.	.	0.12	0.12
Chinook Salmon *(Onchorhynchus tshawytscha)*	-	19.54A	5.34B	3.28C	3.76B,C	1.24D	0.24D
Rainbow Trout *(Salmo gairdneri)*	.	.	0.12	.	0.24	.	.
Brown Trout *(Salmo trutta)*	.	0.85B,C	4.50A	1.09B,C	1.70A,B,C	1.22B,C	0.24C
Lake Trout *(Salvelinus namaycush)*	-	20.54A	27.53A	12.38B	8.26B	12.64A,B	20.05A,B
Lake Whitefish *(Coregonus clupeaformis)*	-	1.46A,B	0.24B	3.64A,B	4.61A	2.55A	0.61A,B
Lake Herring *(Coregonus artedii)*	-	3.04B	7.77A	2.19B	4.97B	1.46B	.C
Round Whitefish *(Prosopium cylindraceum)*	.	1.70	.	.	.	.	.
Whitefish x Herring *(Coregonus sp.)*	.	0.12	.	.	.	.	.
Rainbow Smelt *(Osmerus mordax)*	-	22.07A	16.01A	22.82A	59.03A	55.98A	160.23A
Northern Pike *(Esox lucius)*	+	0.12	0.36	.	1.09	0.36	.
White Sucker *(Catastomus commersoni)*	+	12.52A	2.43B,C	0.85C	4.37B	0.61C	0.36C
Redhorse Sucker *(Moxostoma sp.)*	+	.	0.12	.	.	.	0.36
Lake Chub *(Couesius plumbeus)*	.	.	.	12.68	.	.	.
Common Carp *(Cyprinus carpio)*	.	.	.	.	.	.	0.12
Brown Bullhead *(Ictalurus nebulosus)*	+	0.24C	8.14A	9.21A,B	1.70B,C	7.38A,B,C	0.49B,C
Channel Catfish *(Ictalurus punctatus)*	+	.	.	0.24	0.12	0.12	3.04
American Eel *(Anguilla rostrata)*	.	.	0.36	1.21	.	0.24	.
Burbot *(Lota lota)*	.	.	0.24	0.12	.	.	.
Trout-perch *(Percopsis omiscomaycus)*	.	.	.	0.36	0.36	0.97	1.69
White Perch *(Morone americana)*	+	0.24B	0.61B	0.36B	0.36B	5.32A	14.80A
White Bass *(Morone chrysops)*	+	.	.	0.12	0.49	.	0.36
Rock Bass *(Ambloplites rupestris)*	+	7.53B	7.41B	3.28B	10.05B	40.61A	23.79A
Pumpkinseed *(Lepomis gibbosus)*	+	.	0.73	.	.	.	0.12
Smallmouth Bass *(Micropterus salmonides)*	+	.C	0.12C	25.62B	0.85C	10.33B	27.46A
Black Crappie *(Pomoxis nigromaculatus)*	.	.	0.12	.	.	.	.
Yellow Perch *(Perca flavescens)*	+	158.01C	245.77B,C	.D	110.33B	157.65A,B	263.05A
Walleye *(Stizostedion vitreum vitreum)*	+	1.70D	1.09D	2.92C	2.19C,D	12.99B	31.47A
Freshwater Drum *(Aplodinotus grunniens)*	+	.	0.49	0.97	0.61	1.82	2.19

Table 2. Water temperature at the gillnet transect locations. Mean temperatures with the same letter grouping are not significantly different.

Area	Temperature (C)	Grouping
Brighton	15.2	C
Wellington	16.0	B, C
Rocky Point	16.1	B, C
Flatt Point	16.1	B, C
Grape Island	16.9	B
Melville Shoal	19.0	A

Table 3. Catch at the three Kingston basin transects. Means, for a single species, with the same letter are not significantly different between years.

	Year		
Species	1986	1987	1988
Alewife	1150.39A	449.79B	194.06B
Lake Trout	26.17A	15.72A	13.65A
Lake Whitefish	0.57B	1.05B	2.59A
Lake Herring	2.47A	1.54A	2.14A
American Smelt	47.06A	35.30A	91.74A
Brown Bullhead	3.32A	2.22A	3.19A
White Perch	5.67A	5.13A	6.79A
Rock Bass	26.05A	43.53A	24.82A
Smallmouth Bass	9.80A	12.89A	12.88A
Yellow Perch	331.41A	214.64B	177.01B
Walleye	6.89A	10.61A	15.55A
Walleye (Melville Sh)	13.37B	17.86A,B	31.47A

Table 4. Mean fork length (mm) of alewife caught in the nearshore index gillnets. Means for one location with the same letter are not significantly different.

Area	1986	1987	1988
Flatt Point	138B	136C	141A
Grape Island	139A	137A	139A
Melville Shoal	132B	139A	138A

Indices of Exploitation for Yellow Perch in Eastern Lake Ontario

Yellow perch catches in the Kingston basin (as shown by the index transects at Melville Shoal, Grape Island, and Flatt Point) during the 1988 and 1987 programs were significantly lower than during 1986 (Table 3). The changes in the perch catch are due to a reduction in the catch of fish smaller than the size marketable by the commercial fishery (ie. ≤7.5", Fig. 2). The catch of marketable yellow perch (>7.5" total length) in 1988 was higher than 1986 though not as high as 1987. The fork length at age data for the Kingston basin do not suggest over-exploitation (Fig. 3).

The catch of marketable yellow perch near Brighton was very low in 1988, as it has been since 1982 (Fig. 2). High numbers of fish less than marketable size were caught suggesting that the fish will continue to be recruited to the commercial fishery. The fork length at age data shows that during 1988 very few fish grew to be larger than 150 mm (5.9") regardless of age (Fig. 3). This is consistent with over-exploitation of yellow perch by the commercial gillnet fishery which selects strongly for larger fish. In the past, female yellow perch near Brighton have generally reached sexual maturity at approximately 150 mm (5.9"). During the 1988 sampling all the female fish greater than 100 mm (3.9") were sexually mature. Reductions in the size at which fish become sexually mature are most likely due to size selective over-exploitation.

July and August data from the LOFU research Bay of Quinte index gillnet data series was used to provide information comparable to data from the other locations. In the upper section of Bay of Quinte, the catches of marketable and below marketable sized yellow perch were low in 1988 (Fig. 2). This has been the case for all the recent years except 1980. The catches in the Middle Bay were typical. The fork length at age data for the upper, middle and lower sections of the Bay do not suggest any dramatic changes have occurred recently. They do suggest fast growth in the upper section of the bay relative to the middle and lower sections. This could be due to differences in the exploitation rate, the amount of food available or other factors.

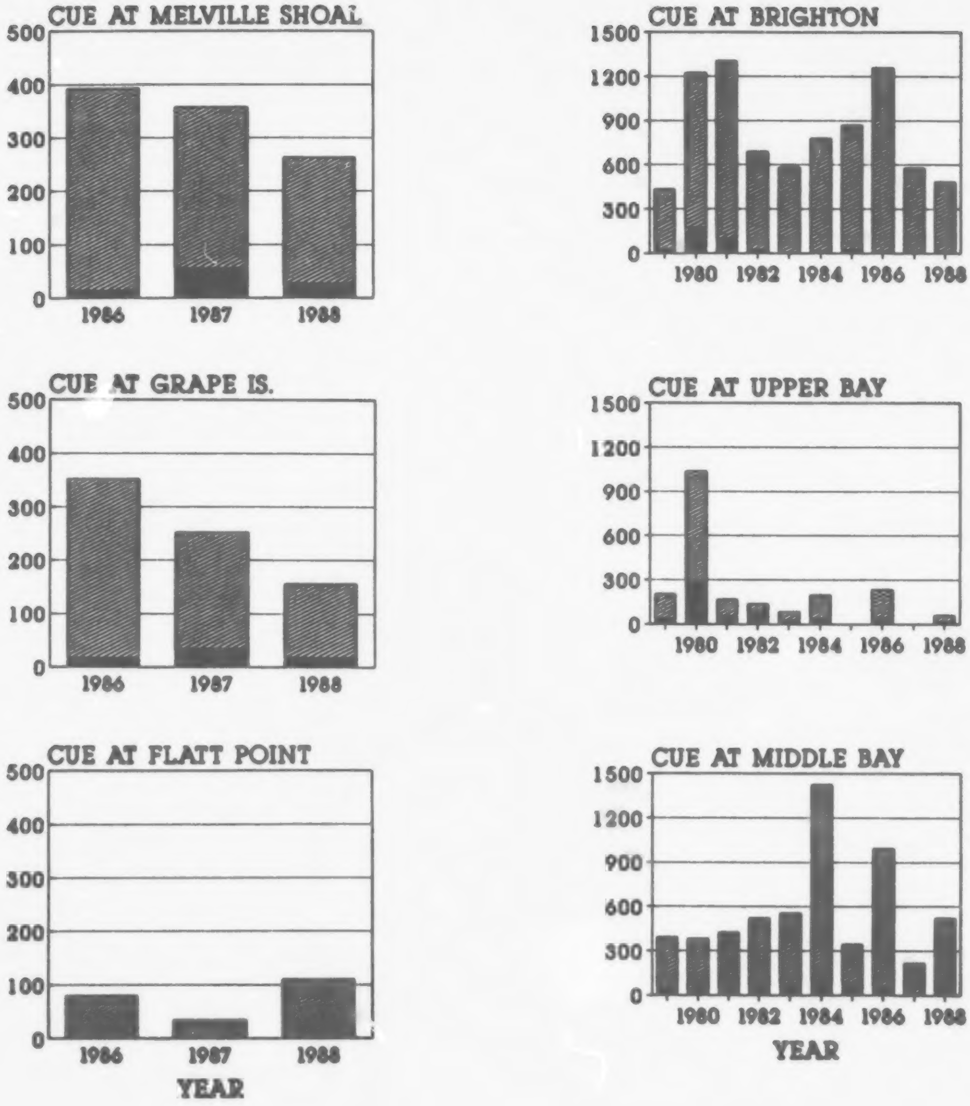

Figure 2. Catch of yellow perch in LOFU gillnets during recent years at several locations in eastern Lake Ontario. The hatched area of the bars represents perch of less than marketable size (ie. ≤7.5"). The solid area of the bars represents perch of marketable size (ie. >7.5"). Only perch caught in July and August were used from the Bay of Quinte dataset to allow comparison to the other locations.

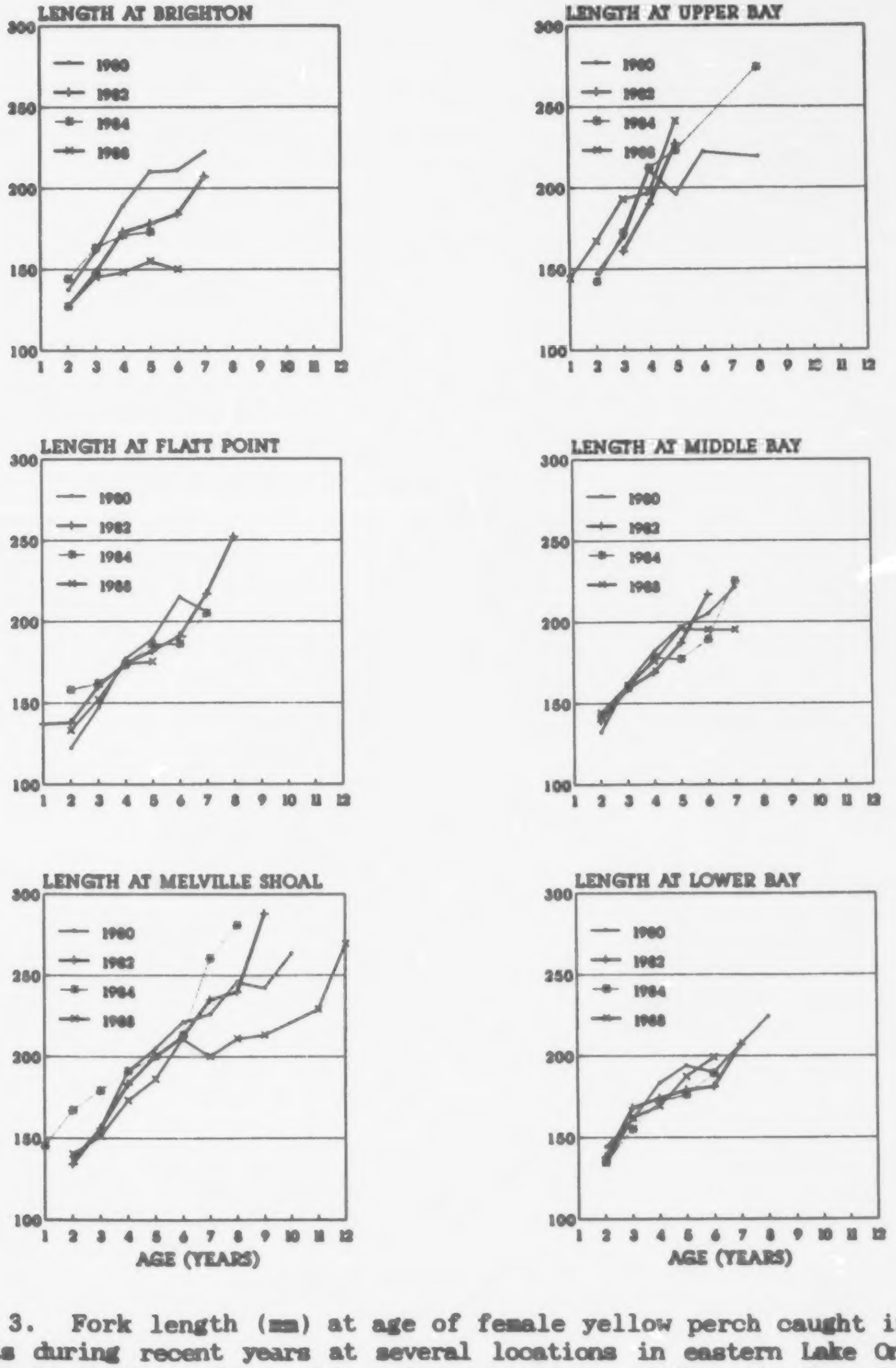

Figure 3. Fork length (mm) at age of female yellow perch caught in LOFU gillnets during recent years at several locations in eastern Lake Ontario. Only female perch caught in July and August were used from the Bay of Quinte dataset to allow comparison to the other locations.

REFERENCES

BOWLBY, J.N. 1988. Whitefish populations in eastern Lake Ontario and the Bay of Quinte. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 88.1.

MALONE, B., W. DENTRY, AND T. SCHANER 1986. Index gillnetting project. Lake Ontario Fisheries Unit, Ontario Ministry of Natural Resources, Internal Report LOA 86.14.

Great Lakes Fishery Commission
Lake Ontario Committee
March 21-22, 1989
Buffalo, New York

WESTERN LAKE ONTARIO HARVEST ASSESSMENT, 1988

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ABSTRACT

The 1988 salmonid fishery of the western basin of Lake Ontario was monitored by means of trailer counts at all public access points and completed trip creel surveys at six major sites. The survey covered April 1 to September 30 and was stratified by month, day type (weekday/weekend day or holiday), and time period. Total estimated fishing effort at individual access points ranged from 21,864 rod-hours at Whitby to 70,013 rod-hours at Bluffer's Park. Based on trailer counts, spring activity was concentrated on the south shore, while mid-summer and fall activity was more evenly distributed with Toronto and Port Credit areas predominating. The total estimated effort in 1988 was 621,555 rod-hours resulting in a harvest of 59,764 salmonids weighing 250,006 kg. Chinook salmon was the dominant harvested species by number (50.8%), followed by rainbow trout (32.1%), coho salmon (11.0%), brown trout (3.1%), lake trout (2.4%) and Atlantic salmon (0.3%). Based on fin clip frequency, 45.9 % of the brown trout harvest originated from Canadian stockings while most of the harvested coho salmon, and rainbow trout were of unknown or American origin. Lamprey marking rates of harvested fish are reported. Returns of adult coho suggest that fall stocked fingerlings survived better than or equal to spring stocked yearlings. Total basin effort was relatively unchanged compared to 1987 while harvest of chinook salmon and lake trout decreased and harvests of coho salmon, rainbow trout, and brown trout increased. Since 1986, chinook salmon harvest has declined by 46%. Further statistical analysis of the Toronto Star Derby chinook catch-per-unit-effort (CUE), at several sites and time periods, confirmed this trend.

RECOMMENDATIONS

1) Continue to attempt to broaden the scope and increase the cost-effectiveness of the creel design by:
    a) developing empirical models that estimate fishing effort from trailer counts and,
    b) surveying of charter boat, moored boat, and shore anglers.
2) Further investigate the decline in chinook abundance by:
    a) estimating recruitment and total mortality rate of salmon harvested during the Toronto Star Derby (1977-1988) to determine if survival of local stockings has changed and,
    b) determine if growth and condition of salmon has also declined in recent years.
3) Mark all stocked salmonids.
4) Uniquely mark 100,000 chinook salmon to be stocked in the Credit River in 1989.
5) Discontinue stocking of rainbow trout in Lake Ontario and maintain natural reproduction by habitat protection and enhancement.
6) Discontinue the monitoring of lamprey marking during the creel survey, until 1992.
7) Collect aging material from rainbow trout, brown trout, and Atlantic salmon in 1989.

INTRODUCTION

The salmonid fishery in the western basin of Lake Ontario has been monitored since 1977. Early assessment concentrated on monitoring individual fishing derbies. Basin wide surveys did not begin until 1985 (Daniels and Savoie, 1986) and were continued in 1986 and 1987 (Daniels and Kristmanson 1987; Stewart 1988).

The survey results apply only to anglers that launch their boats daily at public access points. The charter boat effort and harvest is estimated through mail surveys (Stewart and Samiec 1989). The magnitude of moored boat and shore angler effort and harvest remains unknown. The following report details the results of the 1988 survey and examines recent trends in the fishery.

METHODS

The creel survey design was based on completed trip creel surveys at six major access points from which anglers launch their boats daily (Fig. 1). Sampling stratification was by month (April-September), time period (3-3 hour strata) and day type (weekdays and weekends or holidays). Survey results were expanded to estimated catch, effort and harvest for the entire western basin (Cobourg to Niagara) of Lake Ontario, based on counts of boat trailers at all access points stratified by month. Estimates were also derived for each of the four Ontario Ministry of Natural Resources (O.M.N.R.) districts (Fig. 1) from separate expansion factors. More detailed survey methods are described in Stewart (1988). Changes to the 1988 survey design include, the addition of one surveyed access point (Port Darlington), an earlier survey period in April (1000-1900 hours) and the measurement of weight from a subsample of harvested fish .

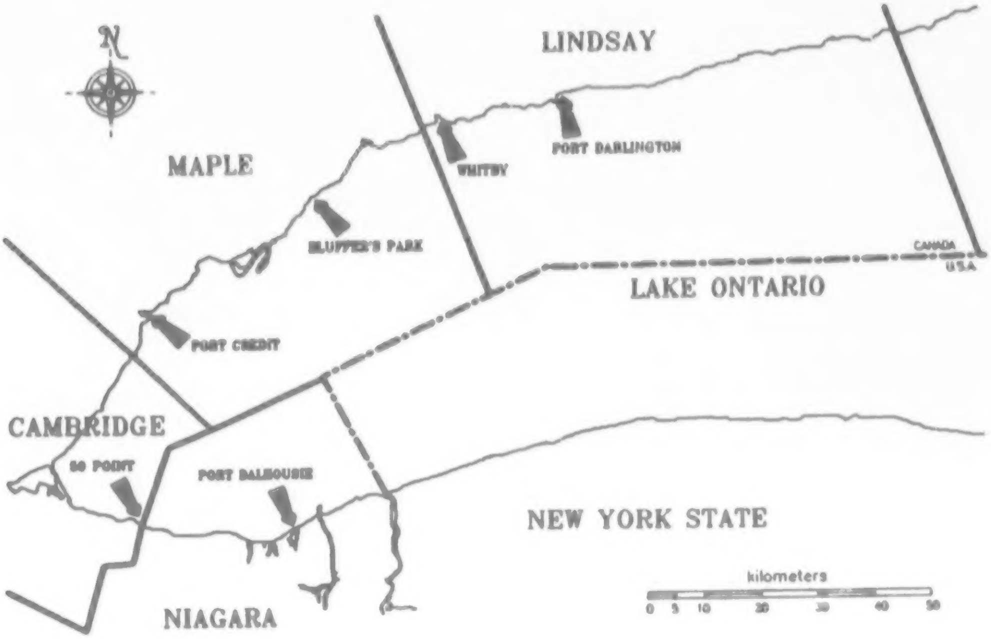
N
LINDSAY
MAPLE
WHITBY
PORT DARLINGTON
BLUFFER'S PARK
CANADA
U.S.A.
LAKE ONTARIO
PORT CREDIT
CAMBRIDGE
50 POINT
PORT DALHOUSIE
NEW YORK STATE
kilometers
0 5 10 20 30 40 50
NIAGARA

Figure 1. Ontario Ministry of Natural Resources administrative district boundaries and location of surveyed access points in western Lake Ontario.

RESULTS

Sampling intensity was similar at each of the surveyed access points (Table 1). Fishing effort ranged from 21,864 rod-hours at Whitby to 77,013 rod-hours at Bluffer's Park. The number of anglers per boat, and mean trip length varied little between access point. The number of boat trips ranged from 2,270 at Whitby to 7,212 at Bluffer's Park corresponding to a range of between 4,900 and 15,434 angler trips per access point. The estimated catch of salmonids ranged from 3,973 at Whitby to 17,359 at Bluffer's Park corresponding to a range in harvest of between 2,300 to 8,670 salmonids. From 37.9 to 68.7 percent of the salmonids caught were released, lake trout were released at a rate of between 57.1 and 85.1 percent. Observed catch-per-unit-effort (CUE) varied from 0.103 (9.7 hours/salmonid) at Port Credit to 0.222 (4.5 hours/salmonid) at Port Darlington.

Most anglers (77.4%) were local, travelling less than 42 km (25 miles) to fish and the majority (55.5%) indicated that 75-100% of their fishing trips occurred on Lake Ontario where they fished for salmon and trout (Table 2). Angler experience varied with the most common (35.2%) level of experience being 2 to 4 years.

The percent relative fishing activity at all access points, based on trailers counts and corrected for the proportion of non-fishing boats, is shown in Table 3. Access point use varied over the season. Activity in spring was concentrated on the south shore, the most active sites being Port Dalhousie and Fifty Mile Point. During midsummer and fall, activity was more evenly distributed between access points but the Toronto and Port Credit areas predominated. The total relative percent activity represented by the surveyed access points ranged from 45.7 to 60.1 percent.

From counts of trailers remaining at the end of the survey period, it was estimated that from 18.8% to 31.0% of the total fishing activity was missed by ending the access survey at 2000 or 1900 hours (Table 4). The highest percent activity missed was estimated for July and August.

The expansion factors used to prorate the access surveys to the entire western basin were derived by multiplying the reciprocals of the proportions of both the total relative activity surveyed and the missed fishing activity (Table 4). These expansion factors were applied to estimate basin statistics by month (Table 5). Separate expansion factors were applied to determine basin statistics for each O.M.N.R. district (Table 6).

Species harvests were multiplied by species mean weight to derive estimates of the total harvest by weight (Table 7). The total harvest of salmonids in 1988 was estimated at 250,006 kg. Chinook salmon was the dominant species in the harvest by number (50.8%). Rainbow trout comprised 32.1% of the harvest and coho salmon 11.0%. Brown trout and lake trout comprised 3.1 and 2.4% of the harvest, respectively.

Table 1. Summary of the 1988 salmonid fishery in Western Lake Ontario by surveyed access point.

STATISTICS	SITE					
	Port Dalhousie	Fifty Mile Point	Port Credit	Bluffer's Park	Whitby	Port Darlington
# interviews	1,626	943	1,559	2,173	754	722
Total # of 3-hr. strata sampled	168	153	156	162	154	162
% parties registered in a derby	74.0	41.6	57.4	73.5	66.3	58.8
Mean # boats counted/hr.	3.8	2.2	3.8	5.5	1.7	1.5
Total estimated effort (rod-hrs.) [SE]	53,451 [4,606]	29,047 [2,008]	51,126 [3,154]	77,013 [4,190]	21,864 [1,341]	19,794 [1,543]
Mean # anglers/boat	2.2	2.2	2.2	2.1	2.2	2.2
Mean trip length (hrs.)	5.0	4.7	4.6	5.0	4.5	4.6
Estimated # boat trips	4,854	2,815	5,076	7,212	2,270	1,965
Estimated # angler trips	10,776	6,193	11,066	15,434	4,902	4,322
Estimated catch of salmonids (# fish) [SE]	12,092 [1,660]	5,254 [669]	5,488 [529]	17,359 [2,024]	3,973 [572]	4,494 [653]
Estimated harvest of salmonids (# fish) [SE]	3,721 [523]	2,985 [396]	3,660 [374]	8,670 [846]	2,330 [318]	2,725 [380]
% released (all salmonids)	68.7	43.4	33.9	46.8	38.0	37.9
% lake trout released	85.1	68.2	74.3	71.9	57.1	71.4
Catch of salmonids/rod-hr. (observed)	0.197	0.177	0.103	0.200	0.170	0.222
# hrs. to catch a salmonid	5.1	5.6	9.7	5.0	5.9	4.5

Table 2. Summary of responses characterizing anglers in the 1988 creel survey.

a) Distance travelled to fish Lake Ontario

Category (miles)	0-10	11-25	26-50	51-100	> 100
%	51.0	26.4	10.6	7.0	5.0

b) Percent of annual fishing trips fishing salmon and trout on Lake Ontario

Category	<25%	25-49%	50-74%	75-100%
%	15.5	8.8	20.2	55.5

c) Number of years fishing salmon and trout in Lake Ontario

Category (years)	1	2-4	5-7	8-10	>10
%	11.5	35.2	20.0	14.5	18.9

Table 3. Relative activity (%) during 1988 at all access points based on trailer counts corrected for the proportion of non-fishing boats. Surveyed access points are indicated by the asterisks. The total % relative activity surveyed is the sum of the % relative activity of surveyed access points.

Access Points	April	May	June	July	August	September
Old Boat Works	2.4	3.4	0.7	0.3	0.2	0.3
*Port Dalhousie	34.1	24.3	4.0	3.8	5.5	11.2
Snug Harbour	0.2	0.2	0.0	0.0	0.0	0.0
Becon Motor Inn	1.3	0.6	0.1	0.1	0.1	0.1
Campbell's Boats	12.0	6.9	5.8	2.8	2.3	5.8
Grimsby Municipal Ramp	2.5	0.7	0.2	0.1	0.5	0.2
Foran's Marine	5.0	4.6	2.8	0.9	1.5	1.4
Lakecourt Marina	3.3	2.0	1.0	0.5	0.6	0.6
*HRCA 50 Point	20.8	14.2	8.1	2.5	5.6	6.4
HRCA Canoe Club	0.1	0.0	1.5	3.9	7.2	4.1
Bronte Beach Park	7.6	7.9	11.2	5.5	9.3	8.5
Coronation Park	0.1	0.7	2.2	0.6	2.5	1.4
Oakville (downstream)	0.0	1.3	2.3	1.2	3.8	0.9
Oakville (upstream)	1.7	1.7	2.3	1.2	2.2	0.6
*Port Credit Public Docks	3.2	4.9	5.8	7.8	15.9	19.7
MTRCA Marie Curtis Park	0.2	1.4	2.8	3.4	4.8	4.7
MTRCA Humber Bay	1.9	6.9	10.1	11.1	9.8	10.6
MTRCA Ashbridges Bay	0.5	3.2	6.9	8.5	4.9	2.5
*MTRCA Bluffer's Park	1.0	9.8	20.0	22.4	13.1	11.2
Whitby Marina	0.01	0.1	0.2	0.2	0.3	0.2
*Whitby Government Ramp	0.02	1.5	4.0	7.9	3.5	2.8
Oshawa Marina	0.03	0.5	1.4	3.5	1.5	1.7
*CLOCA Port Darlington	0.8	1.8	3.8	7.8	2.6	2.3
Port Hope	0.5	0.9	1.2	2.4	1.9	2.5
Cobourg	0.02	0.5	1.5	1.7	0.5	0.3
Total % Relative Activity Surveyed	60.1	58.8	45.7	52.2	46.2	53.6

Table 4. Monthly expansion factors used to prorate 1988 access surveys to the entire western basin.

Month	% Relative* Activity Surveyed	Exp. Factor	% Missed Activity	Exp. Factor	Total Exp. Factor
April	60.1	1.66	18.8	1.19	1.97
May	58.8	1.70	14.9	1.15	1.96
June	45.7	2.19	26.6	1.27	2.78
July	52.2	1.92	30.4	1.30	2.49
August	46.2	2.16	31.0	1.31	2.83
September	53.6	1.87	16.5	1.17	2.19

* from Table 3

Table 5. Summary of the 1988 salmonid fishery in Western Lake Ontario by month.

STATISTICS	April	May	June	July	August	September	Total
# interviews	717	1,292	893	1,992	1,907	976	7,777
Total # of 3-hr. strata sampled	146	180	135	171	152	171	955
% parties registered in one or more derbies	51.5	49.0	61.8	79.2	84.1	27.5	64.4
Mean # boats counted/hr.	1.8	2.8	2.3	4.4	5.0	2.2	3.1
Total estimated effort (rod-hrs.)	46,295	67,481	65,046	169,153	211,509	62,071	621,555
[SE]	[6,856]	[5,790]	[3,576]	[7,995]	[10,929]	[6,647]	[17,913]
Mean # anglers/boat	2.3	2.2	2.1	2.2	2.2	2.1	2.2
Mean trip length (hrs.)	4.3	4.6	4.5	5.0	5.1	4.6	4.8
Estimated # boat trips	4,746	6,609	6,788	15,612	18,963	6,470	59,650
Estimated # angler trips	10,867	14,606	14,391	30,035	91,150	13,523	130,032
Estimated catch of salmonids (# fish)	14,554	7,264	7,359	40,052	39,623	10,578	119,430
[SE]	[1,898]	[797]	[469]	[2,349]	[2,353]	[868]	[4,033]
Estimated harvest of salmonids (# fish)	5,756	2,869	4,818	19,962	20,600	5,758	59,764
[SE]	[592]	[296]	[299]	[1,175]	[1,057]	[457]	[1,799]
% released (all salmonids)	56.4	60.5	33.0	49.2	45.4	44.0	50.0
% lake trout released	69.9	77.3	74.7	83.6	75.0	71.4	76.2
Catch of salmonids/rod-hr. (observed)	0.277	0.102	0.116	0.221	0.175	0.169	0.177
# hrs. to catch a salmonid	3.6	9.8	8.6	4.5	5.7	5.9	5.6

Table 6. Summary of the 1988 salmonid fishery in Western Lake Ontario by O.M.N.R. administrative district.

STATISTICS	DISTRICT			
	Niagara	Cambridge	Maple	Lindsay
# interviews	1,626	943	3,732	1,476
Total # of 3-hr. strata sampled	168	153	318	316
% parties registered in a derby	74.0	41.6	66.7	62.7
Mean # boats counted/hr.	3.8	2.2	4.7	1.6
Total estimated effort (rod-hrs.) [SE]	120,920 [10,014]	101,559 [6,081]	274,884 [10,993]	92,021 [4,570]
Mean # anglers/boat	2.2	2.2	2.2	2.2
Mean trip length (hrs.)	5.0	4.6	4.9	4.5
Estimated # boat trips	10,982	9,843	26,239	9,425
Estimated # angler trips	24,379	21,654	56,677	20,359
Estimated catch of salmonids (# fish) [SE]	27,867 [2,326]	17,359 [1,103]	49,151 [2,526]	18,692 [1,167]
Estimated harvest of salmonids (# fish) [SE]	8,478 [692]	9,538 [660]	26,512 [1,182]	11,180 [672]
% released (all salmonids)	68.7	43.4	43.5	37.9
% lake trout released	85.1	68.2	73.7	66.2
Catch of salmonids/rod-hr. (observed)	0.197	0.177	0.161	0.195
# hrs. to catch a salmonid	5.1	5.6	6.2	5.1

Table 7. Mean fork length, weight and total salmonid harvest for 1988 (N=sample size, standard errors are in brackets, weights were determined from length using seasonally determined length-weight curves.

Species	N	Mean Length (cm)		Mean Weight (kg)		Estimated Harvest (#'s Fish)	% Total Harvest	Estimated Harvest (Wt. in kg)	% Total Harvest
Coho	537	56.1	(0.37)	2.55	(0.053)	6,576	11.0	16,769	6.7
Chinook	1,975	67.6	(0.46)	5.62	(0.096)	30,385	50.8	170,764	68.3
Rainbow trout	1,530	59.1	(0.23)	2.75	(0.033)	19,197	32.1	52,792	21.1
Brown trout	225	51.3	(0.59)	2.40	(0.086)	1,856	3.1	4,454	1.8
Lake trout	153	61.6	(0.62)	3.51	(0.120)	1,421	2.4	4,988	2.0
Atlantic salmon	16	53.9	(1.34)	1.72	(0.158)	139	0.2	239	0.1
Unknown salmonid	-	-	-	-	-	190	0.3	-	-
Totals	4,436					59,764		250,006	

The harvest of Atlantic salmon was less than 1% of the total salmonid harvest. The species composition of the harvest expressed as weight followed the same pattern with chinook comprising 68.3% of the total salmonid harvest by weight.

Species composition of the harvest varied between access points most likely due to seasonal variation in the distribution of effort and species catchability. Generally, as one moves from the south shore clockwise from Port Dalhousie to Port Darlington on the north shore, rainbow trout replaced chinook as the dominant species (Fig. 2).

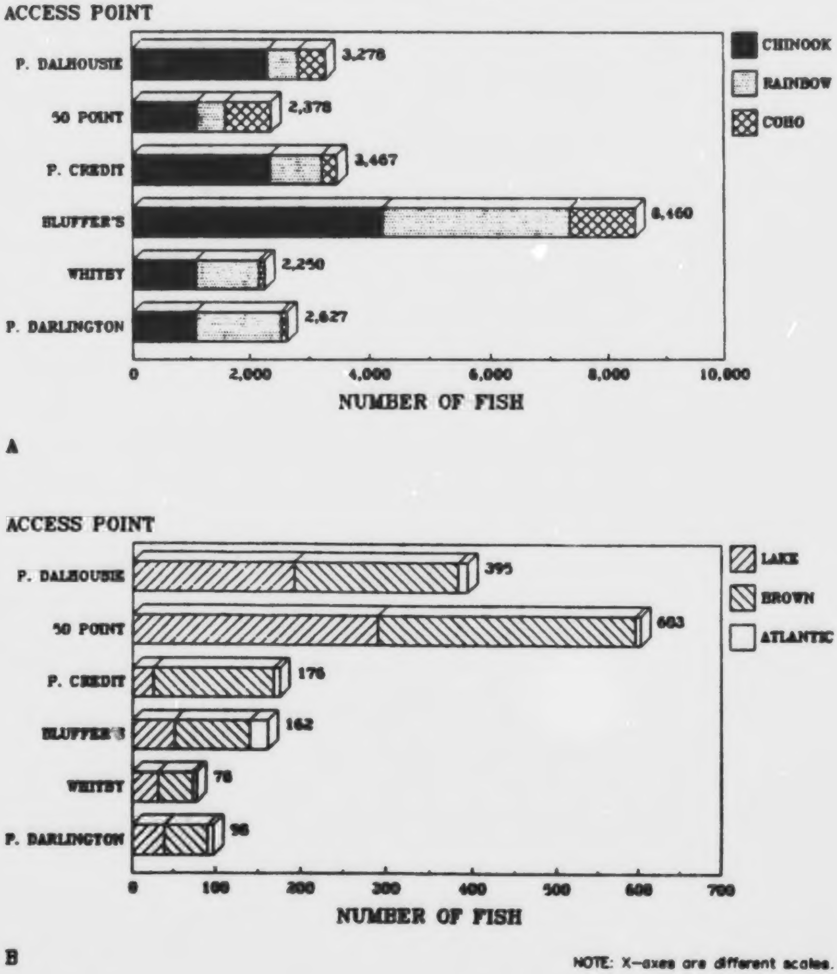

Figure 2. Species composition of the harvest by access point.

Fin clips were recorded for all sampled fish. Interpretation of these data is difficult due to the stocking of a high proportion of unclipped salmonids by both Canadian and American agencies. Seventy-eight percent of coho harvested where unclipped reflecting the high proportion of unclipped coho stocked into Lake Ontario, primarily by American agencies (Table 8). Of the remaining 22% of the coho, 19.2 and 2.2% could be classified as originating from Canadian or American stocking programs, respectively. For rainbow trout, 75.5% of the harvested fish were unclipped. Of the remaining fish, American stocked rainbow trout account for 19.4% of the species harvest while only 4.4 % of the harvest could be attributed to Canadian stockings. Fish of hatchery origin comprised 55.5% of the brown trout harvest, of which 9.9% was American, and 45.9% were Canadian.

The year-class of adult coho harvested this year originated from a planned fall 1986 stocking of fingerlings clipped AdRp, a second unplanned fall 1986 planting of fingerlings (Ad clip) infected with bacterial kidney disease (BKD) and a spring 1987 planting of yearlings clipped Ad (Stewart 1989). The observed proportions of both Ad clipped fish and AdRp clipped fish are contrasted to the expected proportions under two different null hypothesis (Table 9). Hypothesis one is that there is no difference between the survival of the two groups and fish are caught in proportion to their stocking densities. However, poor survival of the BKD fish may have reduced the relative return of the Ad clipped fish. Therefore, hypothesis two is that the BKD fish did not survive and fish are caught relative to the stocking densities of healthy fish only. Hypothesis one was rejected ($p < 0.005$) while there was insufficient evidence to reject hypothesis two ($p > 0.05$) (Table 9), suggesting that healthy fall stocked fingerlings (AdRp clip) survive better than or equal to spring stocked yearlings.

The creel survey provided information on lamprey marking for all salmonids (Table 10).

Recent Trends

Estimates of catch, effort and harvest for the entire western basin of Lake Ontario have been limited to the years 1985-88 and Daniels et al. (1985) determined preliminary estimates for 1984. However, the Toronto Star Great Salmon Hunt has been monitored almost continuously since 1977. As the fishery is largely dependent on stocking and derby activity, total basin activity and species composition of the harvest closely matches trends in the Toronto Star Derby.

Table 8. Fin clip summary for selected salmonids from the Western Basin of lake Ontario 1988. The numbers in brackets are the percent of the total sample.

	Coho	Rainbow Trout	Brown Trout
American fish (left side fin clips and combinations)	12 (2.2)	298 (19.4)	22 (9.9)
Canadian fish (right side fin clips and combinations)	103 (19.2)	67 (4.4)	102 (45.9)
Total clipped	115 (21.4)	365 (23.8)	124 (55.8)
Total not clipped	417 (77.8)	1,158 (75.5)	96 (43.2)
Other clips	4 (0.8)	11 (0.7)	2 (0.9)
Total sample	536	1,534	222

Table 9. Observed harvest of adult Canadian coho salmon stocked as fall fingerlings or spring yearlings. Expected proportions determined from stocking densities (see Stewart 1989). Significant (P<.005) departures from the expected proportion are indicated by an asterisk above the G-test statistic (Sokal & Rohlf, 1981).

Plantings	Clip	Observed Frequency	Observed Proportion	Expected Proportions Hypothesis 1	Expected Proportions Hypothesis 2
Fall 1986	**Ad Rp**	**11**	**0.3143**	**0.1232**	**0.2615**
Fall 1986 BKD/Spring 1987	**Ad**	**24**	**0.6857**	**0.8768**	**0.7385**
G-test statistic				8.8002*	0.5546

Hypothesis 1: Fish were harvested relative to their stocking densities (i.e., no effect of BKD on survival)

2: BKD fish do not survive and fish are harvested relative to the stocking densities of healthy fish only.

Table 10. Summary of the 1988 lamprey marking data.

	Chinook Salmon	Coho Salmon	Rainbow Trout	Brown Trout	Lake Trout
Total # fish samples	1975	537	1530	225	153
Total # marks	57	9	13	17	89
Total # marked fish	53	9	13	12	54
Marking rate	2.89%	1.68%	0.85%	7.56%	58.17%
Incidence of attach[1]	2.68%	1.68%	0.85%	5.33%	35.29%
Total # wounds (AI-II)	23	2	4	5	19
Wounding rate	1.17%	0.37%	0.26%	2.22%	12.42%
Total # scars (AIII-IV, BI-IV)	34	7	9	12	70
Scarring rate	1.72%	1.31%	0.59%	5.33%	45.75%

[1] Incidence of attack = $\frac{\text{\# fish with 1 or more marks}}{\text{total \# fish sampled}} \times 100$

From 1987 to 1988 there was little change in total basin fishing effort or total salmonid harvest (Fig. 3 and 4). However, harvest of chinook has declined from 56,131 in 1986 (Daniels and Kristmanson 1987) to 40,366 in 1987 (Stewart 1988) with a further decline to 30,385 in 1988. This represents a decline of 46% over three years. The drop in chinook harvest in 1988 was mitigated by an increase in rainbow trout (Fig. 4). Historically, these changes are relatively minor. It is apparent from the Toronto Star Derby species CUE's that over the period from 1977-1982 coho salmon dominated the fishery and only recently have they been replaced by chinook salmon and rainbow trout (Fig. 5).

Re-analysis of the 1986-88 survey corresponding to dates and access points associated with the monitoring of the Toronto Star Derby provided a basis for more in-depth comparison. Chinook salmon CUE observed during the derby peaked in 1986 and decline markedly in 1987 and 1988 (Fig. 5). In order to determine if the observed reduction in CUE was due to sampling error, site and season specific CUE's from 1986-88 were compared. Independent estimates of observed chinook salmon CUE's were calculated for each of four 2-week intervals corresponding to the Toronto Star Derby (second Saturday in July to the first Sunday in September) at four access points common to the 1986-88 surveys (Fig. 6). From these data it was concluded that chinook CUE declined significantly from 1986 to 1987 and again from 1987 to 1988 ($p < .05$, paired Wilcoxon signed rank test, Sokal and Rohlf 1981).

DISCUSSION

The current creel design is a compromise between statistical rigour and sampling cost. Estimates of effort, catch and harvest are limited to anglers that launch their boats daily from public access points. Variance components not accounted for in the determination of standard errors include those associated with the trailer counts and fishing to non-fishing boat ratios. The use of trailer counts to prorate the survey results assumes that the trailer counts (corrected for non-fishing boats) are linearly related to estimated effort. This assumption was verified by Stewart (1988). There is evidence to suggest that this relationship is relatively consistent between years and it may be possible to further reduce survey cost by developing empirical models of the relationship between trailer counts and estimated effort. This may reduce the need for some access point surveys in some seasons. Our ability to discern changes in the fishery with a less comprehensive survey is illustrated by our use of the Toronto Star Derby results to examine changes in chinook CUE. Variation in CUE is such that a smaller subset than that illustrated in Fig. 6 may suffice to detect important changes in the fishery. However, modifications of the current design should be implemented with caution to insure that our ability to detect change is not compromised.

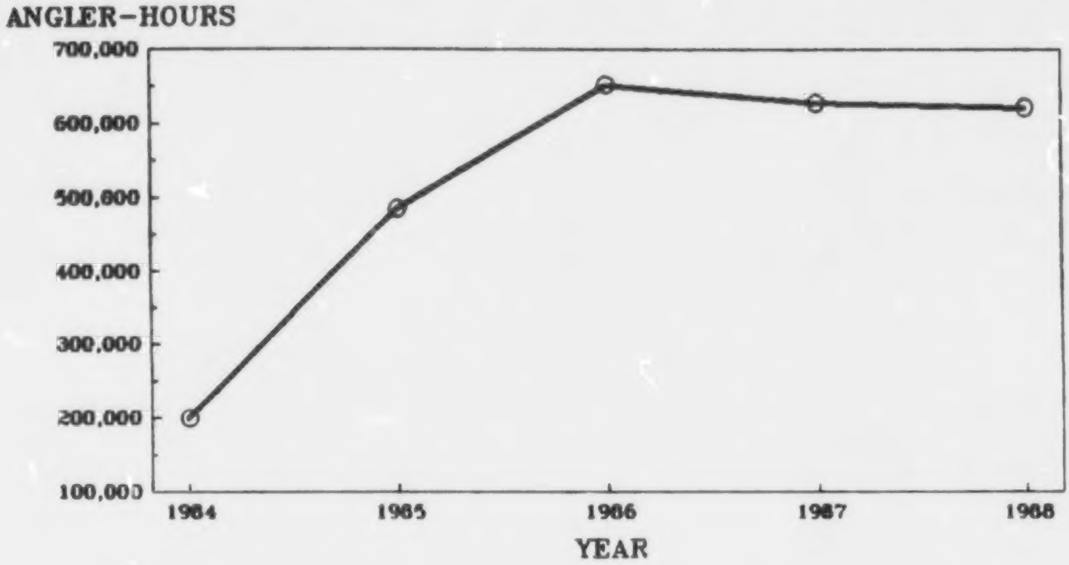

Figure 3. Trend in salmonid boat angler effort in the western basin of Lake Ontario

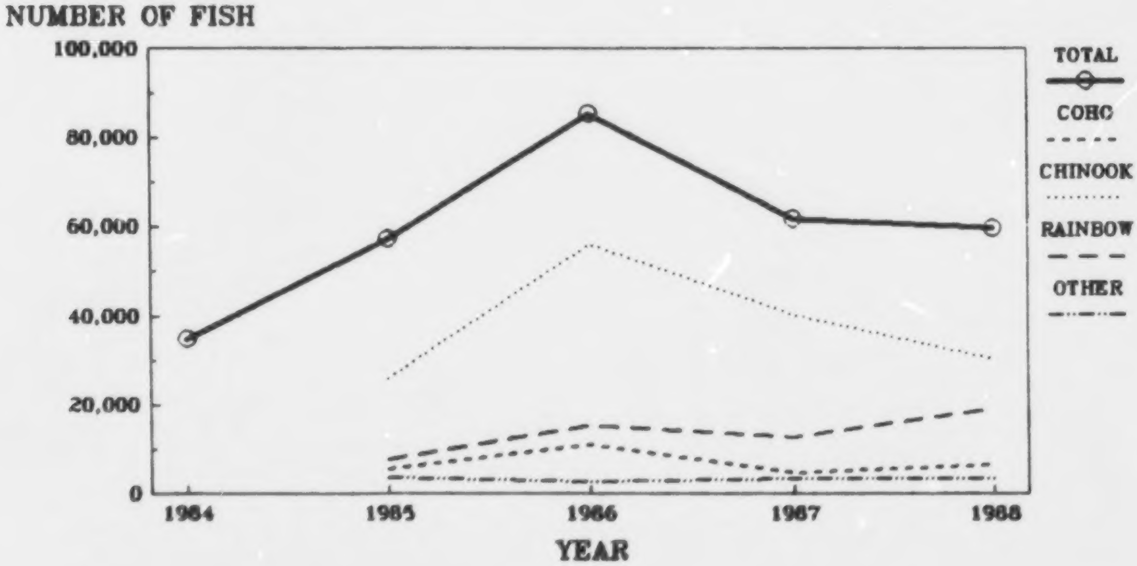

Figure 4. Trend in salmonid harvests in the western basin of Lake Ontario

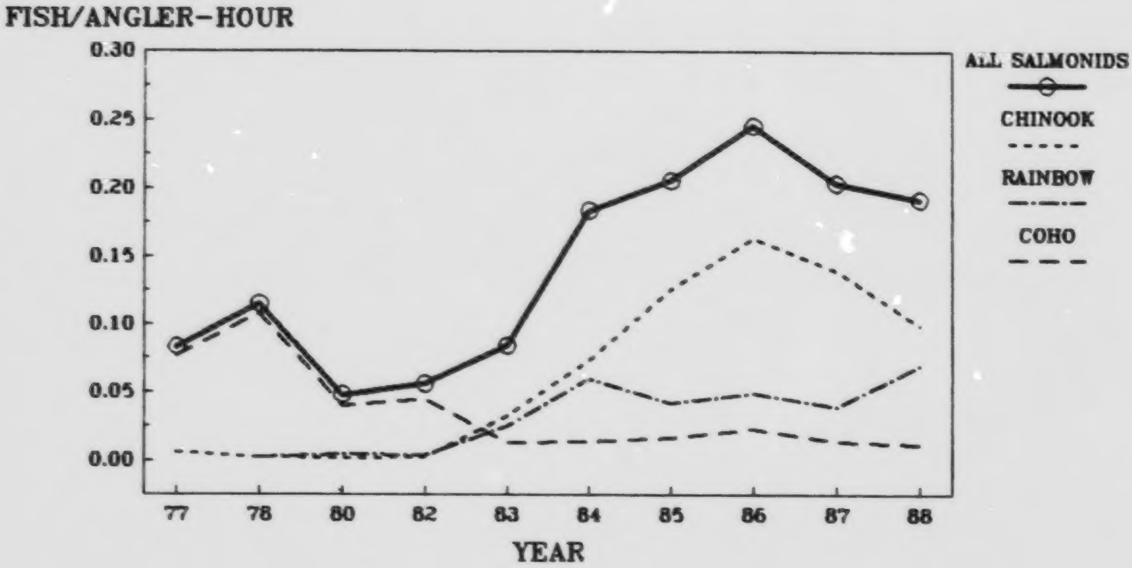

Figure 5. Trend in catch per unit effort (CUE) during the Toronto Star Derby

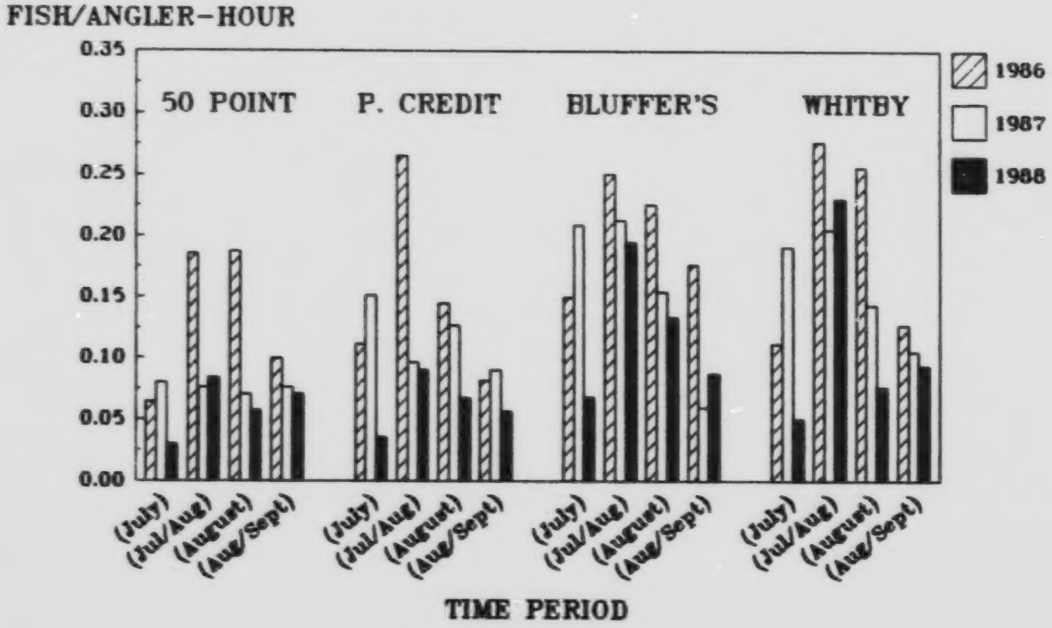

Figure 6. Comparison of chinook catch per unit effort (CUE) at selected access points and time periods corresponding to the Toronto Star Derby

This is the first year that creel statistics were summarized by O.M.N.R districts. Most of the fishing effort, catch and harvest was in Maple district, which had 2-3 times the estimated fishing effort than any other district (Table 6). Variation in salmonid CUE was low, suggesting an equitable distribution of salmonid resources among districts. These summaries should facilitate better application of assessment information to district and regional fisheries management functions.

To facilitate cost effective assessment, as much biological information as is logistically possible should be obtain from sampled fish. Measurements of weight over the entire season in 1988 provides a means to detect changes in species specific condition factors over time. Samples of material to assess fish age should be considered for those species (lake trout, rainbow trout, brown trout, and Atlantic salmon) for which growth cannot be determined easily from length frequency analysis. Fishing derby rules may influence the species composition of the harvest and complicate community or biological interpretations. Higher harvests of lake trout at Port Dalhousie and Fifty Mile Point (Fig. 2) may have resulted from the concentration of effort in spring at these sites and because the St. Catharines Game and Fish Association Salmon Derby (April 16 - May 15) included lake trout as an eligible entry. However, lake trout release rates were highest at these sites (Table 1). Chinook harvest may have been reduced at these sites in spring due to a 20 lb minimum weight for chinook salmon entered in the St. Catharines derby compared to an 8-10 lb minimum in other derbies.

The monitoring of lamprey marking in Lake Ontario is directed at lake trout and spawning populations of Pacific salmon and rainbow trout. (Jolliff et al. 1988). It seems prudent to have independent estimates of lamprey marking rates for salmonids vulnerable to harvest by anglers. However, it may not be necessary to monitor lamprey marking every year.

Recent declines in chinook CUE do not likely represent a chronic problem with local chinook populations, but rather normal variation in a recently established, and artificially maintained fish community. Stocking numbers of chinook have varied little over the last 5 years (Savoie and LeTendre 1989) however, without knowledge of the origin of harvested fish and an understanding of age/size specific angling selectivity it is difficult to interpret changes in CUE relative to stocking rates. We should continue to monitor chinook CUE but also examine trends in total mortality rate, recruitment, growth, and condition. It would also be valuable to determine the distribution of stocked chinook over the season by marking a subsample prior to stocking.

The creel survey has the potential to provide valuable stocking assessment information. The comparison of returns of fall stocked coho fingerlings versus spring yearlings, although confounded by the stocking of the BKD fish, suggests that fall stocking may be a viable alternative for coho salmon. Final recommendations will have to await assessments of paired plantings returning to the fishery in the next few years.

Based on fin clips, returns of Canadian stocked rainbow trout to Ontario anglers are extremely low (4.4%). Although, large numbers of unmarked rainbow trout were stocked in Ontario from 1980-83, they are likely out of the system. The cost and benefits of the Ontario rainbow trout stocking program should be reviewed. However, increased harvests of rainbow trout mitigated the decline in chinook harvests in 1988, emphasizing the need to maintain species diversity and management flexibility.

REFERENCES

DANIELS, M. E., AND J. KRISTMANSON. 1987. Western Lake Ontario Harvest Assessment, 1986. Report to the Lake Ontario Committee, GLFC, March 3-4, 1987.

DANIELS, M. E., D. McLEISH, W. WALTERS, AND T. SCHANER. 1985. Salmonid Assessment Program. Report to the Lake Ontario Committee, GLFC, March 5-6, 1985.

DANIELS, M. E., AND P. J. SAVOIE. 1986. Western Lake Ontario Creel Surveys, 1985. Ontario Ministry of Natural Resources Report. March 1986. 40 pp.

JOLLIFF, T., W. DENTRY, J. ELROD, J. HEINRICH, AND R. McDONALD. 1988. Lake Ontario Sea Lamprey Assessment. Report to the Lake Ontario Committee, GLFC, March 8-9, 1988.

SAVOIE, P. J., AND J. LeTENDRE. 1989. Lake Ontario Stocking and Marking Program. Report to the Lake Ontario Committee, GLFC, March 20-21, 1989.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. Second Edition. W. H. Freeman Co., San Francisco. 877 pp.

STEWART, T. J. 1988. Western Lake Ontario Charter Boat Survey, 1987. Report to the Lake Ontario Committee, GLFC, March 8-9, 1988.

STEWART, T. J. 1989. Credit River Coho Spawning Run. Report to the Lake Ontario Committee, GLFC, March 20-21, 1989.

STEWART, T. J., AND A. SAMIEC. 1989. The 1988 charter boat questionnaire program. Report to the Lake Ontario Committee, GLFC, March 20-21, 1989.

STEWART, T. J., AND P. J. SAVOIE. 1989. Western Lake Ontario Harvest Assessment, 1988. Report to the Lake Ontario Committee, GLFC, March 20-21, 1989.

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CREDIT RIVER COHO SPAWNING RUN

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ABSTRACT

Coho were sampled during the spawning run in the Credit River over the period from November 22-28, 1988. The adult fish represented the fourth successive return of the Big Qualicum River (British Columbia) strain in Lake Ontario . The returning year-class originated from an original fall 1986 planting of 17,000 fingerlings clipped AdRp, a second fall 1986 planting of 73,000 fingerlings (Ad clip) infected with bacterial kidney disease (BKD) and a spring 1987 planting of 48,000 yearlings clipped Ad. Although interpretation was confounded by the stocking of the BKD fish, it was concluded that fall stocked coho had a significantly higher ($p < .001$) return rate than those stocked in spring. Lamprey marking remained low (4.6%). An analysis of variation in the size of returning coho over the period from 1977-1988 showed significant effects due to strain and return sequence, but a significant interaction term in the model precludes generalizations. At first return, there was a pronounced difference in size between the strains. At fourth return, the differences were still evident but less pronounced. A trend to smaller size with successive returns was apparent, but results were equivocal.

RECOMMENDATIONS

1) Maintain monitoring of the coho egg taking operations.

2) Repeat this analysis for coho caught by anglers over the same years.

3) Investigate these results further by:

    a) examining the size differences between the same strains in their native rivers,

    b) determine if coho of different size run the rivers at different times.

INTRODUCTION

The Canadian coho salmon present in Lake Ontario consist of three West Coast strains; Skagit River, Capilano River, and Big Qualicum River. The first plantings of these strains in Canadian waters of Lake Ontario occurred in spring of 1976 (Skagit), 1977 (Capilano), and 1978 (Big Qualicum), with first spawning returns to the Credit River in the fall of 1977, 1978 and 1979 respectively (Table 1). These strains have been monitored continuously since 1977, providing a unique opportunity to examine changes in strain characteristics over time.

Table 1. Strains of Canadian stocked coho in Lake Ontario and years in which they return to the Credit River as adults to spawn.

Strain	First Stocking	Spawning Returns			
		First	Second	Third	Fourth
Skagit River (Washington)	1976	1977	1980	1983	1986
Capilano River (British Columbia)	1977	1978	1981	1984	1987
Big Qualicum River (British Columbia)	1978	1979	1982	1985	1988

The objectives of this study were to:

1) Summarize statistics on length, weight, fin clips, and lamprey marking rates of the 1988 returning coho.

2) Make a preliminary comparison of the spawning returns of fall stocked coho fingerlings versus spring stocked coho yearlings.

3) Test the hypothesis that weight of individual strains of returning coho has declined with successive spawning returns, as suggested by Stewart (1988).

METHODS

Coho eggs and sperm are collected annually from fish sampled by electro-fishing at the Reid Mill Dam, Streetsville, Ontario, in the Credit River during late November to early December. Fertilized eggs are raised at Ringwood Fish Culture Station and stocked into Lake Ontario as either spring yearlings or fall fingerlings. These collections are the sole source of fertilized eggs used in the Canadian coho stocking program. The Lake Ontario Fisheries Unit monitors length, weight, fin clip and lamprey marking rate of fish sampled during the spawning runs.

Coho were sampled in 1988 over the period from November 23 to 28. Previous monitoring information from 1977 to 1987 was reviewed for differences in methodology and data recording that may confound an examination of trends. This included the separation of precocious male and female fish (Jacks and Jills) from summary statistics, and elimination or correction of weights taken from fish stripped of gonadal material or bled prior to weighing. A linear analysis of variance model was applied to the 12 years of data (1977-1988) to partition variance into main and interaction effects of strain and return sequence on length and weight. Separate linear analysis of variance models were applied to examine effects of return sequence for each strain and the effects of strain on each return sequence. The Tukey multiple comparison procedure was used to compare treatment means. This test allows for conclusions based on unplanned paired multiple comparisons and the confidence coefficient applies to the family of comparisons. If not all pairs are of interest the confidence coefficient is conservative (Neter and Wasserman 1974).

RESULTS

1988 Summary Statistics

The adult fish returning in 1988 represented the fourth successive return of the Big Qualicum River (British Columbia) strain (Table 1). The returning year-class originated from a fall 1986 planting of 17,000 fingerlings clipped AdRp, a second fall 1986 planting of 73,000 fingerlings (Ad clip) infected with bacterial kidney disease (BKD) and a spring 1987 planting of 48,000 yearlings clipped Ad. (Table 2). Based on fin clip frequency, 89% (249/280) of the fish sampled in 1988 can be attributed to the 1986 and 1987 planting of the Big Qualicum River strain (Table 3). The observed proportions of both Ad clipped fish (unplanned fall 1986 release of diseased fish and the spring 1987 stocking) and AdRp clipped fish (planned fall 1986 stocking) are contrasted to the expected proportions under two different null hypothesis (Table 4). Hypothesis one is that there is no difference between the survival of the two groups and that fish are caught in proportion to their stocking densities. However, poor survival of the BKD fish may have reduced the relative return of the Ad clipped fish. Therefore, hypothesis two is that the BKD fish do not survive and fish are caught relative to the stocking density of healthy fish only. Both hypotheses were rejected at $p < 0.001$ (G-test statistic, Sokal and Rohlf 1981) leading to the conclusion that the healthy coho first planted in the fall (fingerlings) had a higher survival rate than the same cohort stocked in the spring as yearlings.

Table 2. Recent Canadian coho plantings.

Year of Stocking	Age in 1988	Stocking Site	# Stocked	Size at Stocking (#/1b)	Fin Clip
1986 (fall planting)	2+	Credit River*	73,000	29	Ad
		Credit River	17,000	41	AdRp
1987 (spring (plantings)	2+	Port Dalhousie	68,000	24	Rv
		Bronte Creek	71,000	23	Rv
		Credit River	48,000	19	Ad
Totals	2+		277,000		
1988 (spring planting)	1+	Port Dalhousie	80,000	19	Rv
		Bronte Creek	75,000	20	Rv
		Credit River	52,000	19	Ad
1987 (fall plantings)	1+	Port Dalhousie	39,000	31	AdRv
		Bronte Creek	24,000	32	AdRv
		Credit River	66,000	31	AdRv
Totals	1+		336,000		

* early plant of BKD fish

Table 3. Fin clip frequency and fin clip regeneration of coho sampled from the 1988 spawning run in the Credit River. Fin clip regeneration is estimated usually to the nearest 10% (double clip regeneration is reported as the average regeneration of the two clipped fins) (NC = no clip, Ad = adipose clip, RP = right pectoral clip, Rv = right ventral clip, LP - left pectoral clip).

ADULTS

% Regeneration	NC	RP	Rv	Ad	AdRP	AdLP	AdRv	AdRPLP
0 ≤ 10	-	2	3	135	38	4	2	0
11 ≤ 50	-	1	0	17	57	4	3	1
51 ≤ 89	-	0	0	0	1	0	0	0
90 +	-	0	0	0	0	0	0	0
Total	11	3	3	153	96	8	5	1

JACKS

% Regeneration	NC	Ad	AdLP
0 ≤ 10	-	7	0
11 ≤ 50	-	0	1
51 ≤ 89	-	0	0
90 +	-	0	0
Total	1	7	1

Table 4. Catches of spawning adult coho salmon stocked as fall fingerlings or spring yearlings. Expected proportions determined from stocking densities (Table 2). Significant ($p<.001$) departures from the expected proportions are indicated by and asterisk above the G-test statistic (Sokal and Rohlf, 1981).

Plantings	Clip	Observed Frequency	Observed Proportion	Expected Proportions Hypothesis 1	Expected Proportions Hypothesis 2
Fall 1986	Ad Rp	96	0.3855	0.1232	0.2615
Fall 1986 BKD/Spring 1987	Ad	153	0.6145	0.8768	0.7385
G-test statistics				18.2744*	110.2222*

Hypothesis 1: Fish are caught relative to their stocking density (i.e., no effect of BKD on survival)

2: BKD fish do not survive and fish are caught relative to the stocking densities of healthy fish only.

Lamprey marking remained low (4.6%) relative to data collected prior to 1980 (Fig. 1 and Table 5). Mean adult male coho weight (4544 grams) was significantly larger (t-test, $p < 0.0005$) than mean female weight of 4231 grams (Table 6).

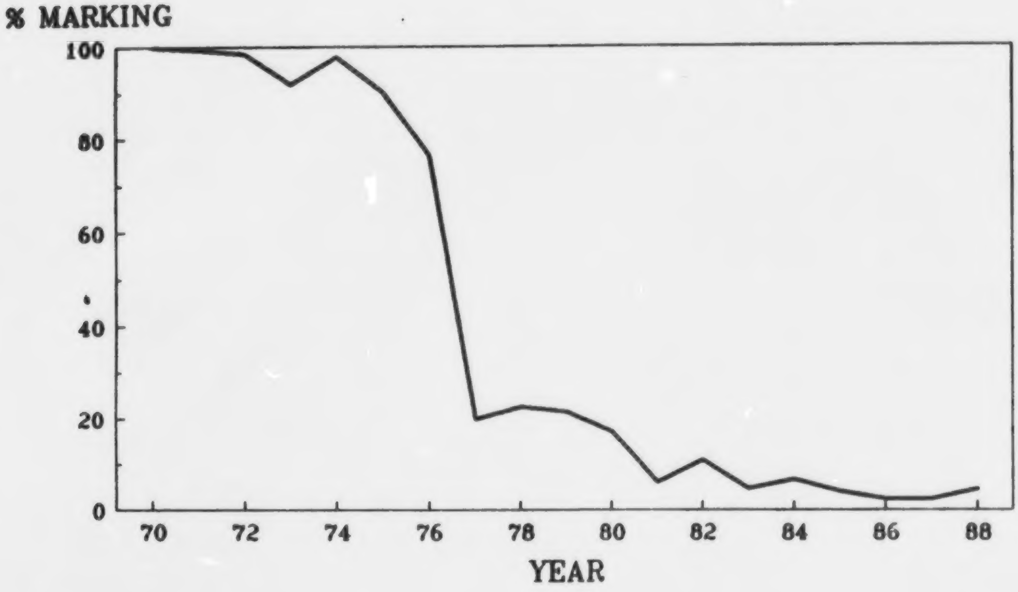

Figure 1. Trends in the rate of lamprey marking on spawning coho in the Credit River.

Size Trends

Stewart (1988) suggested that weight of individual strains of returning coho may have declined with successive spawning returns, however available summary data did not allow separation of confounding effects of sex, and sampling methodology. From 1977-1988 the methods used to measure length and weight were relatively consistent. In 1977, 1979, and 1981 some female fish were stripped of eggs before being weighed. To remove any bias caused by the selection of certain sizes of fish for stripping prior to weighing, a correction equation was developed by regressing round weight (RWT) to stripped weight (STRWT). The equation $RWT = 463.7 + (1.0877 \times STRWT)$ was found to adequately describe the relationship between RWT and STRWT for all years combined ($p < .0001$) and stripped weights were converted to round weights prior to analysis.

Table 5. Lamprey marking on adult coho (FL > 440 mm) from the 1988 egg collection from the Credit River (N=280).

Type	Stage	# Marks	Mean Diameter (mm)
A	I	1	30
	II	3	38
	III	1	32
	IV	4	30
B	I	0	-
	II	1	30
	III	3	30
	IV	0	-

Total # marks	13
Total # marked fish	13
Marking rate	4.6%
Incidence of attack [1]	4.6%
Total # wounds (AI-II)	4
Wounding rate	1.4%
Total # scars (AIII-IV, BI-IV)	9
Scarring rate	3.2%

[1] Incidence of attack = $\frac{\text{\# fish with 1 or more marks}}{\text{total \# fish sampled}} \times 100$

Table 6. Summary statistics for coho from the 1988 egg collection (Credit River).

ADULTS (FL > 440 mm)

Attribute	N	Mean	Min.	Max.	St. Dev.	St. Error
TL (mm)	280	723	620	835	40.43	2.42
FL (mm)	280	680	578	790	39.60	2.37
WT (g)*	280	4,379	2,200	6,700	781.58	46.71

ADULT MALES

Attribute	N	Mean	Min.	Max.	St. Dev.	St. Error
TL (mm)	132	738	620	835	40.70	3.54
FL (mm)	132	693	578	790	40.56	3.53
WT (g)*	132	4,544	2,200	6,700	866.97	75.46

ADULT FEMALES

Attribute	N	Mean	Min.	Max.	St. Dev.	St. Error
TL (mm)	148	710	629	792	35.08	2.88
FL (mm)	148	668	582	753	34.56	2.84
WT (g)*	148	4,231	2,600	6,100	665.66	54.72

JACKS (FL < 440 mm)

Attribute	N	Mean	Min.	Max.	St. Dev.	St. Error
TL (mm)	9	388	311	433	38.72	12.91
FL (mm)	9	361	283	407	39.39	13.13
WT (g)*	9	644	300	800	166.67	55.56

*Weights recorded to the nearest 100 g.

Females were weighed in 1984 after bleeding the fish (a recent practice to avoid contaminating the eggs with excessive blood). An adequate correction factor could not be determined and the 1984 data were not used for the analysis of female weights. In most years it could not be determined if males were weighed before or after being spawned but the amount of sperm collected was less than 100 grams. This inconsistency likely increased the variance in male weights.

Observed fin clip frequencies suggest that the genetic integrity of the individual coho strains has been maintained. Consistent clipping of coho did not begin until 1984 such that only the 1985-88 spawning runs could be evaluated. From these samples it was determined that from 79 to 97% of the adults sampled for eggs and sperm were from the local stocking. The actual percentages were likely higher. Anomalous fin clips of unknown origin were common to all years, suggesting observational or clip application errors resulting in lower observed returns of locally stocked fish.

The results of the analysis of variance (ANOVA) indicated a significant effect due to strain, return sequence and interaction effects on the length and weight of adult male and female coho ($p < 0.0001$). The presence of significant interaction effects precludes generalization about the mean effects of strain or return sequence. However, separate ANOVA's of sequence effects within individual strains and the corresponding analysis of strain effects within individual return sequences revealed some general patterns.

There is an overall trend to decreasing weight for both male and female fish over the study period (Fig. 2). Trends in fork length are less clear. Much of the variation in size evident in Fig. 2 is due to strain differences. Based on a separate ANOVA and Tukey multiple comparison of means, all three strains were significantly different in size at first return, with the order from largest to smallest being Big Qualicum, Capilano, and Skagit (Table 7 and Fig. 3). These strain differences are not maintained consistently over successive returns (Fig. 3). However, in their fourth successive spawning return, the original strain differences were still evident although not all differences were statistically significant (Table 8).

Separate ANOVA's where also done for each strain to assess the effects of return sequence. Graphically there is a trend to smaller weight with each successive return, for both male and female fish of each strain and a general trend to smaller length for female fish. (Fig. 3). No clear trend is apparent in mean strain fork length of male fish. Based on the Tukey test the size at fourth return is significantly smaller than size at first return for all mean strain weights and some mean strain lengths (Table 9). The decrease in weight ranges from 237 to 1193 grams.

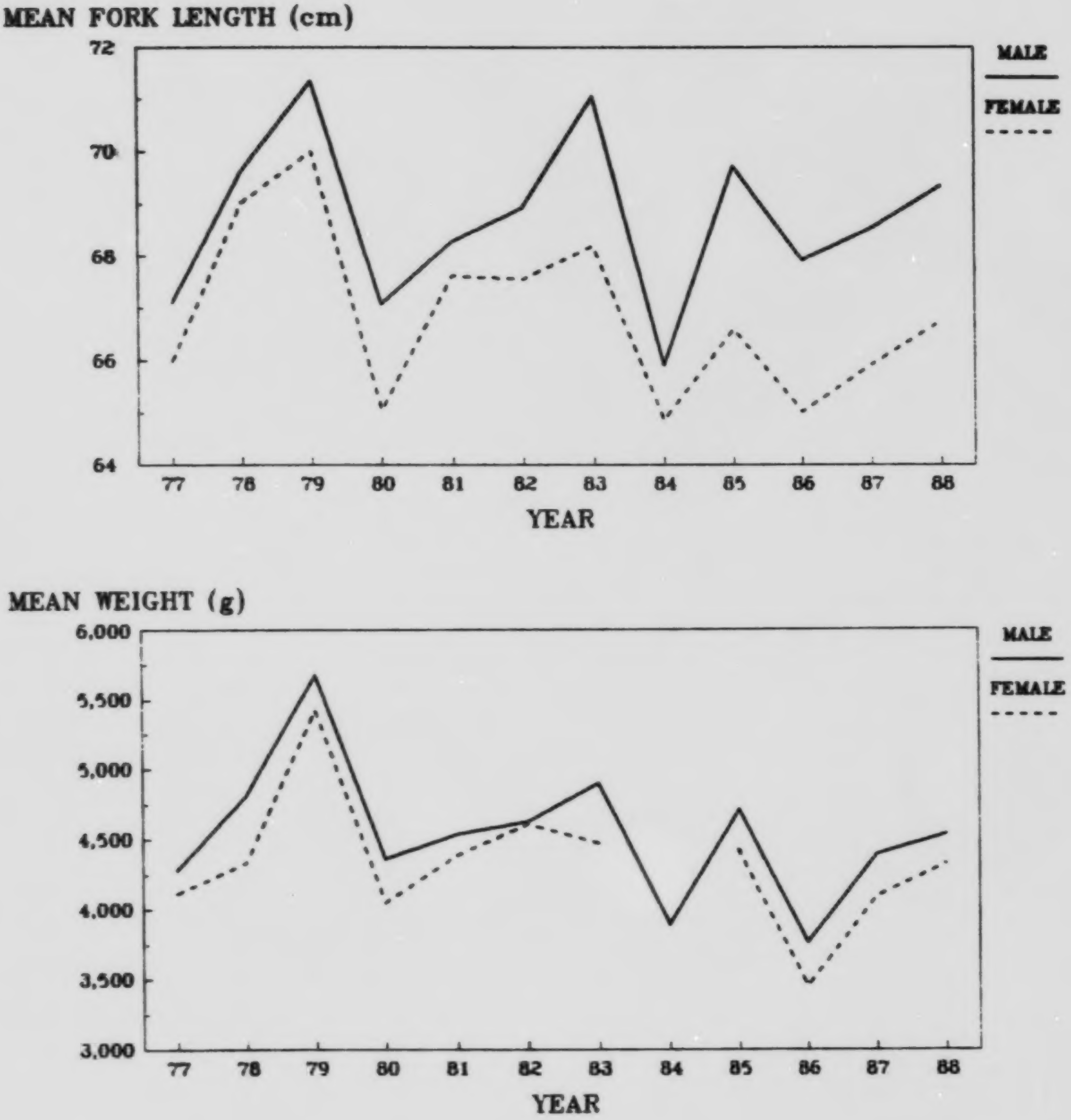

Figure 2. Trends in mean length and weight of spawning adult male and female coho salmon in the Credit River.

Table 7. Mean size of adult coho stocks returning for the first time. All differences between stocks within a sex grouping are significant at $p < .05$ based on the Tukey multiple comparison procedure.

Coho	Stocks		
	Skagit (1977)	Capilano (1978)	Big Qualicum (1979)
Female Weight (g)	4,120	4,337	5,424
Female Fork Length (mm)	660	690	700
Male Weight (g)	4,288	4,816	5,681
Male Fork Length (mm)	671	696	714

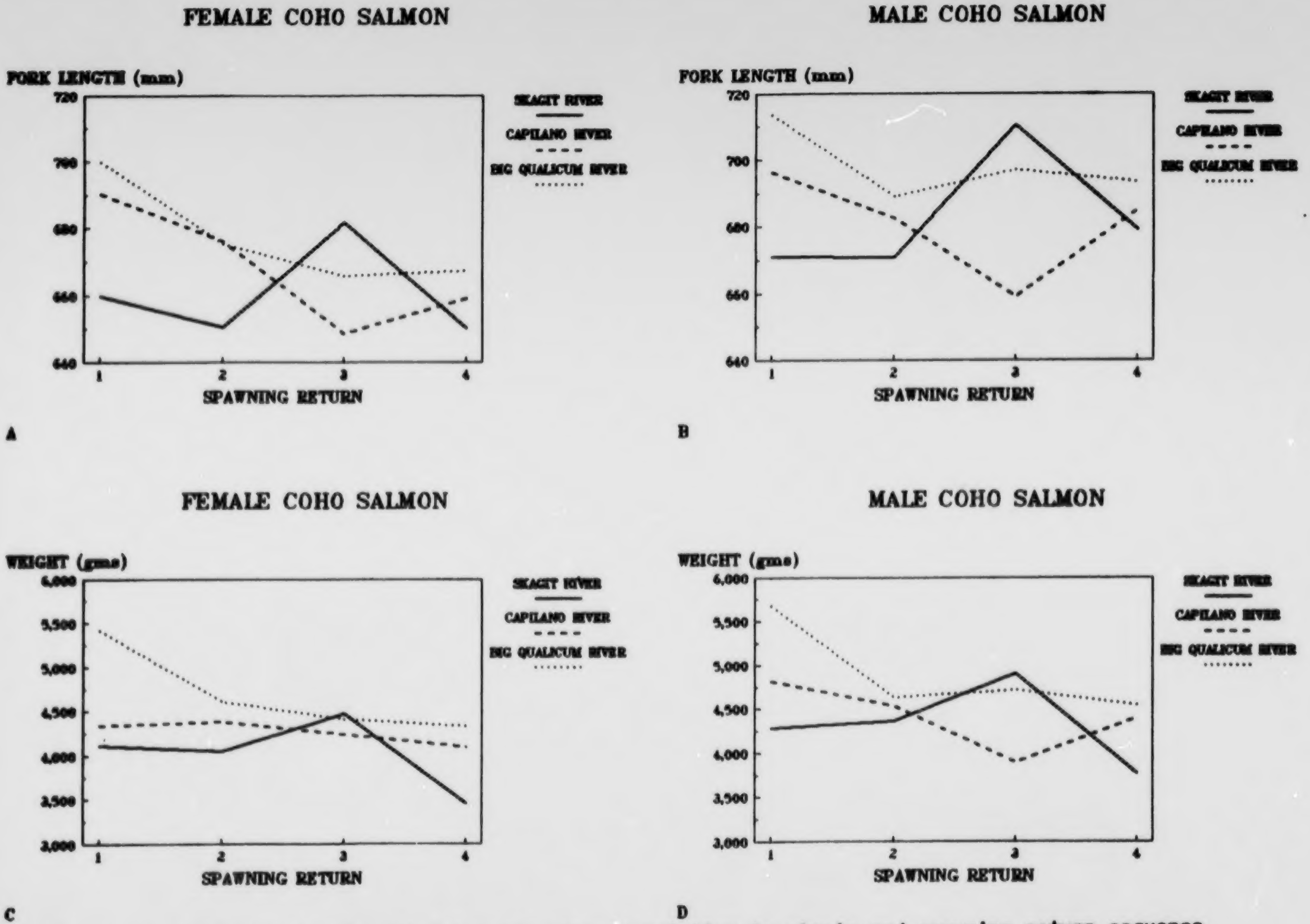

Figure 3. Variation in size of returning coho in relation to strain and spawning return sequence

Table 8. Mean size of adult coho stocks returning to spawn for the fourth time. Differences in size between stocks are significant at $p < .05$ based on the Tukey multiple comparison procedure unless underlined by an overlapping bar.

	Stocks		
Coho	Skagit (1986)	Capilano (1987)	Big Qualicum (1988)
Female Weight (g)	3,458	4,100	4,231
Female Fork Length (mm)	650	659	668
Male Weight (g)	3,771	4,400	4,544
Male Fork Length (mm)	679	685	693

Table 9. Differences in weight and fork length between first and fourth successive returns of spawning adult fish. An asterisk indicates a significant difference at $p < .05$ based on the Tukey multiple comparison procedure.

	Female		Male	
Stock	Weight (g)	Fork Length (mm)	Weight (g)	Fork Length (mm)
Skagit	- 662*	- 10	- 516*	- 8
Capilano	- 237*	- 31*	- 416*	- 11
Big Qualicum	- 1,193*	- 32*	- 1,138*	- 20*

DISCUSSION

The higher than expected return for the planned fall 1986 planting (AdRp clip) suggests that fall stocking is a viable alternative for coho. The proportions observed in angler harvests support this conclusion. There was a significantly higher ($p < 0.005$) proportion of AdRp clipped coho harvested than expected based on overall stocking densities and no significant difference ($p > .05$) based on stocking densities of healthy fish only (Stewart and Savoie 1989). Monitoring of subsequent runs will provide the direct comparison of spring and fall planting returns, and recommendations concerning coho stocking policy should await these results.

Growth is expressed through environmental influences on the genotype of each coho strain. Genetic differences among the strains, maintained through the collection and artificial propagation of fertilized eggs, accounts for some of the variation in the size of the returning coho. The hypothesis of a decreasing weight over successive spawning returns, particularly for female fish, was supported by this study although the trend was not consistent among strains. This is most apparent for the third return of the Skagit River strain which occurred in 1983. In this year the size of the fish was the largest observed for this strain (Fig. 3). The higher growth was likely due to favourable environmental conditions such as temperature, population density, higher prey abundance, or reduced competition from other salmonids. An alternative explanation may be that due to the timing of the spawning run in 1983, collections were biased for larger fish. To investigate this further, a similar analysis should be done on the size of adult coho harvested by anglers over the same period.

The reason for a decline in size could be due to a decline in prey abundance associated with increased salmonid stocking. Alternatively, egg collection and propagation procedures may inadvertently result in a the selection of smaller adults. For example, larger fish may be better able to avoid capture during egg collections or ascend the rivers later in the spawning run. Further monitoring and analyses are warranted.

REFERENCES

NETER, J., AND W. WASSERMAN. 1974. Applied linear statistical models. Richard D. Irwin, Inc., Illinois.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. (2nd Ed.) W. H. Freeman and Company, San Francisco.

STEWART, T. J. 1988. Monitoring coho spawning run in the Credit River. Report to the Lake Ontario Committee, GLFC, March 8-9, 1988.

STEWART, T. J., AND P. J. SAVOIE. 1989. Western Lake Ontario Harvest Assessment, 1988. Report to the Lake Ontario Committee, GLFC, March 21-22, 1989.

Great Lake Fishery Commission
Lake Ontario Committee
March 21-22, 1989
Buffalo, New York

LAKE ONTARIO CHARTER BOAT QUESTIONNAIRE PROGRAM, 1988

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ABSTRACT

The reported charter boat effort was 104,962 rod-hours corresponding to an estimated effort of 288,083 rod-hours. Assuming a catch-per-unit-effort (CUE) of 0.10 to 0.22 salmonids per hour (Stewart and Savoie 1989), the charter operators caught between 28,808 and 63,378 salmonids. Based on the 1988 western Lake Ontario launch daily angler catch statistics, the charter boats accounted for an additional 19 to 35% of the salmonid catch and an additional 32% of the total estimated effort.

RECOMMENDATIONS

1. Determine a statistically rigorous estimate of total seasonal charter boat effort, catch and harvest for both associated and non-associated charter boat operators by:

    a) interviewing charter boat operators in the field at the completion of their trip to obtain information on catch and harvest by species, size distribution of catch, numbers of rods per trip, fishing start and end times, and charter association membership,

    b) conducting mail and phone surveys to determine the mean numbers of trips per month from a random sample of charter boat association members.

INTRODUCTION

Charter boat operators generally do not launch their boats daily but moor their boats at public and private marinas. Therefore, charter boat operator fishing effort cannot be determined from access point surveys at launch daily boat ramps. An unknown, but a suspected large, proportion of operators belong to charter boat association and can be contacted through mail surveys. While response to these surveys is voluntary, it does offer a means to derive a tentative estimate of charter boat fishing effort and catch.

METHODS

The charter boat questionnaire program (Kristmanson and Daniels 1987; Stewart 1988) was continued in 1988. Survey forms (Kristmanson and Daniels 1987) were sent to all members of the Ontario Charter Boat Association (OCBA), the Indepentdent Charter Boat Association (ICBA) and the Scarborough Charter Boat Association (SCBA). Voluntary responses from each association were expanded to estimate rod effort based on the number of registered members. The range in estimated salmonid catch was determined by using the observed range in salmonid CUE determined for launch daily anglers (Stewart and Savoie 1989).

RESULTS

The total membership increased from approximately 180 members in 1987 (Stewart 1988) to 246 in 1988 (Table 1). The number of respondents increased from 151 to 181. However, the response rate dropped slightly from 45 to 38%. An error in the fall questionnaire may have contributed to a decreased response rate. The reported charter boat effort was 104,962 rod hours corresponding to an estimated effort of 288,083 rod-hours. Assuming a range in CUE of 0.10 to 0.22 salmonids per hour (Stewart and Savoie 1989), the charter operators caught between 28,808 and 63,378 salmonids. Based on the 1988 western Lake Ontario launch daily angler catch statistics (Stewart and Savoie 1989), the charter boats accounted for an additional 19 to 35% of the salmonid catch and an additional 32% of the total estimated effort. OCBA represents 66% of the total charter fishing effort, ICBA represents 23% and SCBA 10%. The overall estimated charter fishing effort is largely unchanged from 291,083 in 1987 (Stewart 1988) to 288,083 angler hours in 1988 (Table 1). The fishing effort for non-member charter operators is not known. The most frequently used ports were Port Credit, Bluffer's Park (and Scarborough area), and Bronte (Table 2). The greatest percentage of the trips occurred in July and August (58% combined) with an average of 21 trips per operator for each of these two months (Table 3). The months of July through September represent 74% of the total fishing effort for the survey period (Table 4). Throughout the survey period, Bluffer's Park, Port Credit and Bronte are the ports that have the greatest proportion of the total effort. The mean number of rods per trip is 3.8 - 4.4, the mean trip length is 4.5 - 4.8 hours and the mean rod hours per trip is 20.4 - 22.8 (Table 5).

Table 1. Summarized survey results by charter boat association. (OCBA = Ontario Charter Boat Association, ICBA = Independent Charter Boat Association, SCBA = Scarborough Charter Boat Association). Members belonging to more than one association were arbitrarily assigned to the first association listed.

	April - June			July - September			
	OCBA	ICBA	SCBA	OCBA	ICBA	SCBA	Total
Membership (N)	135	74	37	135	74	37	-
Questionnaires							
Sent* (n)	134	72	36	127	68	37	472
Received (r)	56(42%)	34(47%)	10(28%)	48(38%)	25(37%)	8(22%)	181(38%)
Charter Owner Respondents							
Operating	45(80%)	29(85%)	9(90%)	45(94%)	22(92%)	6(87%)	156(87%)
Nonoperating	11	5	1	3	2	1	23
Expansion Factor**	2.40	2.14	3.63	2.71	2.81	4.62	-
Reported Effort (rod-hours)	16,423	9,325	1,416	55,844	16,128	5,826	104,962
Estimated Effort (rod-hours)	39,415	19,955	5,140	151,337	45,320	26,916	286,605
% Total Estimated Effort	13.7	6.9	1.8	52.5	15.7	9.3	-

* excludes misaddressed and other anomalies

** Expansion factor = $[(n/r) + (N-n)/n]$

Table 2. Frequency of port use by charter boat operators in 1988.

Port	April	May	June	Spring Totals	% Spring Port Use	July	Aug.	Sept.	Fall Totals	% Fall Port Use	April-Sept. Totals	% Total Port Use
St. Catharines	4	6	4	14	7.4	2	2	2	6	2.8	20	5.9
Grimsby	10	9	5	24	12.8	2	2	2	6	2.7	30	7.4
Fifty-Point Marina	1	1	1	3	1.6	4	3	3	10	4.5	13	3.2
Hamilton/Burlington	6	5	6	17	9.0	2	4	4	10	4.5	27	6.6
Bronte	7	6	8	21	11.2	7	7	7	21	9.5	42	10.3
Oakville	1	1	2	4	2.1	2	2	2	6	2.7	10	2.5
Port Credit	12	14	26	52	27.6	18	19	16	53	24.1	105	25.7
Toronto	0	1	1	2	1.1	3	2	2	7	3.2	9	2.2
Scarborough/ Bluffer's Park	4	8	12	24	12.8	15	15	15	45	20.5	69	16.9
Pickering/ Frenchmen's Bay	3	5	6	14	7.4	6	6	5	17	7.7	31	7.6
Whitby	0	2	3	5	2.7	4	4	2	10	4.6	15	3.7
Oshawa	1	1	4	6	3.2	6	6	5	17	7.7	23	5.6
Port Darlington	0	0	0	0	0.0	1	1	1	3	1.4	3	0.7
Cobourg	0	1	1	2	1.1	1	1	1	3	1.4	5	1.2
Unknown Port	0	0	0	0	0.0	2	2	2	6	2.7	6	1.5
Total	50	61	79	188	100.0	82	82	82	220	100.0	408	100.0

Table 3. Trips per month by charter boat operators in 1988.

Month	# Trips	% Trips within a 3-Month Period	% Trips by Month	Mean Number of Trips per Operator
April	177	15	4	7
May	394	34	9	11
June	596	51	14	16
July	1,065	35	25	21
August	1,408	46	33	21
September	603	19	14	19
Total	4,243			

Table 4. Charter boat operator effort in rod hours by month and location in 1988.

Port	April	May	June	Spring Totals	% of Year	July	Aug.	Sept.	Fall Totals	% of Year	Year Totals	% of Year
St. Catharines	0	210	0	210	0.2	72	120	240	432	0.4	642	0.6
Port Dalhousie	44	802	612	1,458	1.4	336	264	192	792	0.8	2,250	2.1
Grimsby	1,521	1,960	617	4,090	3.9	120	600	240	960	0.9	5,058	4.9
Fifty-Point Marina	0	72	108	180	0.2	732	844	542	2,118	2.0	2,298	2.2
Hamilton/Burlington	504	893	743	2,140	2.0	178	609	632	1,419	1.4	3,559	3.4
Bronte	873	1,444	1,893	4,210	4.0	1,763	3,938	1,791	7,492	7.1	11,702	11.2
Oakville	30	120	300	450	0.4	624	1,134	360	2,118	2.0	2,568	2.5
Port Credit	805	1,612	4,717	7,134	6.8	4,892	9,417	3,048	17,357	16.5	24,491	23.3
Toronto	0	546	560	1,106	1.1	2,199	886	657	3,742	3.6	4,848	4.6
Scarborough/ Bluffer's Park	110	898	2,625	3,633	3.5	6,499	8,854	4,217	19,570	18.6	23,203	22.1
Pickering/ Frenchmen's Bay	40	308	722	1,070	1.0	1,410	2,420	960	4,790	4.6	5,860	5.6
Whitby	0	74	292	366	0.3	964	952	160	2,076	2.0	2,442	2.3
Oshawa	0	0	589	589	0.6	4,726	4,310	1,322	10,358	9.9	10,947	10.4
Port Darlington	0	0	0	0	0.0	690	720	630	2,040	1.9	2,040	1.9
Cobourg	0	40	200	240	0.2	563	337	67	967	0.9	1,207	1.1
Unknown Port	0	20	260	280	0.3	655	622	289	1,566	1.5	1,846	1.8
Total	3,927	8,999	14,238	27,164	25.9	26,423	36,027	15,347	77,797	74.1	104,961	100.0

Table 5. Average effort per charter boat operator in 1988.

Season	Mean # of Rods/Trip	Mean Trip Length (hr)	Mean Rod Hours/Trip
Apr - June	3.8	4.5	20.4
Jul - Sept	4.4	4.8	22.8

REFERENCES

DANIELS, M. E., AND J. KRISTMANSON. 1987. Lake Ontario Charter Boat Questionnaire Program, 1986. Report to the Lake Ontario Committee, GLFC, March 3-4, 1987.

STEWART, T. J. 1988. Lake Ontario Charter Boat Questionnaire Program, 1987. Report to the Lake Ontario Committee, GLFC, March 8-9, 1988.

STEWART, T. J., AND P. J. Savoie. 1989. Western Lake Ontario Harvest Assessment, 1988. Report to the Lake Ontario Committee, GLFC, March 21-22, 1989.

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ONTARIO MINISTRY OF NATURAL RESOURCES (OMNR)
and
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION (DEC)
1989 LAKE ONTARIO COMMITTEE REPORT

LAKE ONTARIO STOCKING AND MARKING PROGRAM

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INTRODUCTION

The Lake Ontario fish stocking and marking program report is prepared annually to present numbers of fish stocked and identifying marks used on fish stocked into Lake Ontario by OMNR and DEC.[1/] Tables 1 and 2 provide statistics on numbers of fish stocked in 1987 and 1988 and numbers of fish proposed for 1989 stocking. Tables 3 and 4 provide information on numbers of fish stocked into Lake Ontario from 1968 through 1988 by both agencies. Tables 5 and 6 provide detailed information about the areas of Lake Ontario that were stocked in 1988. In addition, these tables (5 and 6) include species information including strain, hatchery of origin, size at stocking and marks. Table 7 shows the deviations from the proposed 1988 stocking and explains the reasons for the changes.

The proposed stocking by OMNR and DEC for 1989 is presented as numbers of fish by species, expected age of stocking, and proposed stocking sites in Tables 8 and 9.

Comparison of OMNR and DEC Lake Ontario stocking is shown as abundance of each species by percent in Figure 1 and as actual numbers by age group in Figure 2. The trend in increased stocking by both agencies is shown in Figure 3 and the trends by species of fish stocked by both agencies combined is depicted in Figure 4.

[1/] All lake trout stocked by DEC were provided by United States Fish and Wildlife Service from the Allegheny National Fish Hatchery. Penobscot strain Atlantic salmon were provided by United States Fish and Wildlife Service from Tunison Laboratory at Cortland National Fish Hatchery. Private groups raised walleye fry provided by the DEC and stocked them as fingerlings.

RESULTS

The 1988 Lake Ontario fish stocking by all agencies consisted only of salmon and trout. Private groups in New York raised and stocked walleye from fry provided by DEC from the Constantia Fish Hatchery. The total number of salmonids and walleye stocked in all Lake Ontario waters combined was 8,614,000. The stocking of 2,702,600 salmonids in Province of Ontario waters was slightly above the number proposed for 1988 stocking. The New York stocking of 5,850,300 salmon and trout was also above the proposed goal.

The surplus consisted of yearling and fingerling coho salmon stocked by Ontario, a large number of coho spring and fall fingerlings stocked by New York, and excess yearling rainbow trout stocked by OMNR and over 200,000 excess rainbow trout fingerlings stocked by both agencies combined.

The stocking of large numbers of excess coho and rainbow trout fingerlings should make up for the slight DEC shortages of yearlings of these species. Both agencies are still having problems reaching yearling stocking goals for brown trout and Atlantic salmon and combined with the recent dip in New York's lake trout yearlings these shortages are keeping the agencies from reaching proposed stocking goals.

Due to concerns about the ability of the Lake Ontario forage base to sustain increasing levels of salmonid stocking, OMNR and DEC have agreed in principle to a lakewide stocking cap of 8.2 million (±5 percent) fish annually. There were 613,000 surplus fingerling fish stocked into Lake Ontario which caused the 8.2 million limit to be exceeded by 7.5 percent (Figure 3). Poorer survival of these surplus fish suggests that combined stocking may not produce excess adult fish in the lake.

TERMINOLOGY

Following are explanations for some of the terms and abbreviations used in the following tables.

Steelhead:	a migratory rainbow trout, technically, one which undergoes the parr-smolt transformation and migrates to Lake Ontario from the stream in which it was planted, or hatched in the case of wild fish.
Domestic Rainbow trout:	a rainbow trout that is not known to exhibit a parr-smolt transformation and, therefore, is planted directly into the lake since it would not be expected to migrate to the lake if planted in a stream.
Mark:	body part removed or tag added for identification
LV:	Left Ventral fin
Ad-LV:	Adipose and Left Ventral fins
RV:	Right Ventral fin
Ad-LP:	Adipose and Left Pectoral fins
LV-RV:	Both Ventral fins
RP:	Right Pectoral fin
LP:	Left Pectoral fin
LV-LM:	Left Ventral fin and Left Maxillary bone
CWT:	Coded Wire Tag (60-42-14; the first two numbers are the agency code; i.e. 60 and 63 are the agency codes for DEC and OMNR respectively, the third through sixth numbers identify individual lots of fish)

Table 1. Salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1987 and 1988 and proposed for 1989.

Species	Age	Number Stocked 1987	Number Stocked 1988	Number Proposed 1989
Brown Trout	Yearling	256,362	387,309	435,000
	Fingerling	62,331	0	0
	Adult[1/]	210	342	0
	Total	318,903	387,651	435,000
Coho	Yearling	187,662	207,099	160,000
	Fingerling	212,593	165,829[3/]	80,000
	Total	400,255	372,928	240,000
Lake Trout	Yearling	1,066,152	1,023,572	1,150,000
	Fingerling	55,592	0	0
	Total	1,121,744	1,023,572	1,150,000
Chinook	Fingerling	513,931	516,207	650,000
Rainbow Trout	Yearling	306,060	264,140	175,000
	Fingerling		110,964	
	Total	306,060	375,104	175,000
Atlantic Salmon	Yearling	0	27,145	50,000
	Fingerling	1,009	0	0
	Total	1,009	27,145	50,000
	TOTAL	2,661,902	2,702,607	2,700,000

[1/] Adult = 35 to 46 month old broodstock fish

[2/] Subject to public consultation during fisheries management planning

[3/] Fingerling includes 90,007 fall fingerlings and 75,822 spring fingerlings

TABLE 2. Salmon and trout stocked in New York waters of Lake Ontario in 1987, 1988, and proposed for 1989.

Species	Age	Number Stocked 1987	Number Stocked 1988	Number Proposed 1989
Brown Trout	Yearling	417,800	404,300	500,000
	Fingerling	0	46,400	0
	Total	417,800	450,700	500,000
Coho	Yearling	80,000	299,800	350,000
	Fingerling	0	256,400[1]	0
	Total	80,000	556,200	350,000
Lake Trout	Yearling	818,100	767,500	1,020,000
	Fingerling	366,600	247,100	180,000
	Total	1,184,700	1,014,600	1,200,000
Chinook	Fingerling	3,111,300	2,848,000	2,700,000
Rainbow Trout				
Washington Steelhead	Yearling	418,300	293,700	330,000
	Fingerling	129,400	269,400[4]	0
	Total	547,700	563,100	330,000
Domestic	Yearling	90,600	77,400	115,000
	Fingerling	40,200	150,500[2]	23,000
	Total	130,800	227,900	138,000
Skamania	Yearling	25,000	107,000	82,000
Finger Lakes (wild) x Domestic	Yearling	0	6,800	
Finger Lakes (wild)	Fingerling	0	38,600[3]	0
Atlantic Salmon	Yearling	58,100	31,900	49,000
	Fingerling	7,100	5,500	0
	II+	100	0	0
	Total	65,300	37,400	49,000
	TOTAL	**5,562,600**	**5,850,300**	**5,349,000**

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[1] 80,000 surplus spring fingerlings are included in this number

[2] Includes 127,500 surplus fingerlings

[3] 38,600 surplus fingerlings

[4] 269,400 surplus fingerlings

TABLE 3. Approximate numbers (in 1000's) of salmon and trout planted in Province of Ontario waters of Lake Ontario from 1968 through 1988.

Species	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Coho Y	0	138	148	160	122	272	438	226	166	313	201	156	77	169	112	142	106	191	183	188	207
Coho F	0	0	0	0	0	0	0	0	0	0	0	130	172	165	0	76	0	0	90	129	90
Coho f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	76
Chinook f	0	0	0	89	190	0	225	0	0	0	393	147	18	12	270	125	662	703	598	514	516
Lake Trout Y	0	0	0	0	0	0	0	0	194	288	200	201	383	387	391	372	493	729	852	1066	1024
Lake Trout F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	0
Brown Trout II+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0**
Brown Trout Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	123	122	136	283	256	387
Brown Trout F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	27	14	62	0
Brown Trout f	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
Rainbow Trout Y	12	10	10	18	107	28	30	7	108	110	114	201	149	81	68	105	110	106	200	306	264
Rainbow Trout F	0	0	0	0	0	30	94	0	0	0	10	0	0	0	0	0	0	0	0	0	111
Rainbow Trout f	0	0	0	0	0	0	0	22	0	0	0	0	180	0	0	0	0	0	0	0	0
Atlantic Salmon Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
Atlantic Salmon F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Splake Y	24	25	0	0	48	39	26	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Kokanee f	0	20	45	50	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kokanee fry	228	334	1982	678	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	264	527	2185	995	528	369	813	255 **	474 **	711 **	918	835	979	821	889	943	1494	1893	2221	2662	2702

Legend:		
	II+:	Two year old fish
	Y:	Yearlings, stocked between January and June usually 5" to 9"
	F:	Fall fingerlings, stocked between September and December usually 3½" to 6"
	f:	Spring fingerlings, stocked May and June usually 2½" to 3"

* Does not include planting of 15,000 rainbow trout eggs in 1975 or lake trout eggs planted in 1976 (90,000) and 1977 (200,000).

** There were 346 adult brown trout stocked (spent brood stock) in 1988.

Table 4. Approximate numbers (in 1000's) of salmon, trout and walleye planted in New York waters of Lake Ontario from 1968 through 1988.

Species	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Coho Y	25	119	294	122	230	215	147	452	177	40	40	175	0	0	307	396	289	351	194	80	300
Coho F	15	0	0	0	0	25	69	361	0	0	40	169	299	0	60	51	454	25	268	0	176
Coho f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	0	80
Chinook f	0	70	140	100	426	691	963	920	593	0	0	222	788	1468	1808	2759	3878	3022	2849	3111	2848
Chinook F	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout Y	0	0	0	0	0	66	128	0	63	0	505	492	1012	1031	1054	1086	1045	984	1012	818	768
Lake Trout F	0	0	0	0	0	0	517	513	274	298	538	193	182	112	205	11	0	202	370	367	247
Lake Trout II+	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Brown Trout Y	0	0	0	0	0	60	81	108	157	162	94	219	257	365	503	479	408	440	442	418	404
Brown Trout F	0	0	0	0	0	0	42	113	153	195	0	0	272	89	153	100	0	0	0	0	46
Brown Trout f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98	132	0	0	0	0	0
Rainbow Trout Y	0	0	0	0	0	0	19	0	54	50	41	41	85	76	38	108	93	84	80	91	77
Rainbow Trout F	0	0	0	0	0	0	10	99	106	67	125	167	411	147	96	105	105	105	23	40	150
Rainbow Trout f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	549	0	0	0
Steelhead Y	0	0	0	0	0	0	50	0	29	24	147	117	263	260	114	112	293	334	407	443	407
Steelhead F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10	55	129	308
Brook Trout F	0	0	0	0	0	0	0	0	0	0	0	0	326	106	0	0	0	0	0	0	0
Atlantic Salmon Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	25	55	55	58	32
Atlantic Salmon F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	7	6
Walleye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	3	63
SALMON TOTAL	40	189	434	222	656	1066	2026	2566	1607	823	1530	1795	3895	3656	4441	5528	6590	6174	5840	5562	5849
WALLEYE TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	3	63
GRAND TOTAL	40	189	434	222	656	1066	2026	2566	1607	823	1530	1795	3895	3656	4441	5528	6590	6174	5860	5565	5912

Legend:
II+: Two year old fish
Y: Yearlings, stocked between January and June usually 5" to 9"
F: Fall fingerlings, stocked between September and December usually 3½" to 6"
f: Spring fingerlings, stocked May and June usually 2½" to 3"

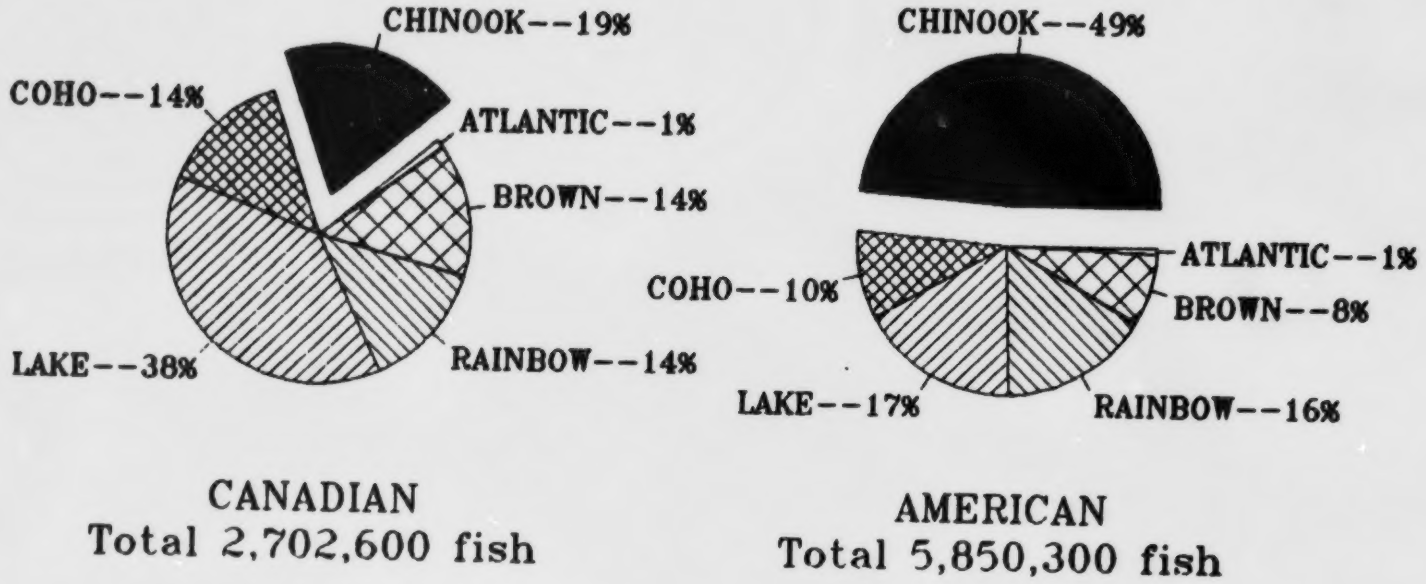
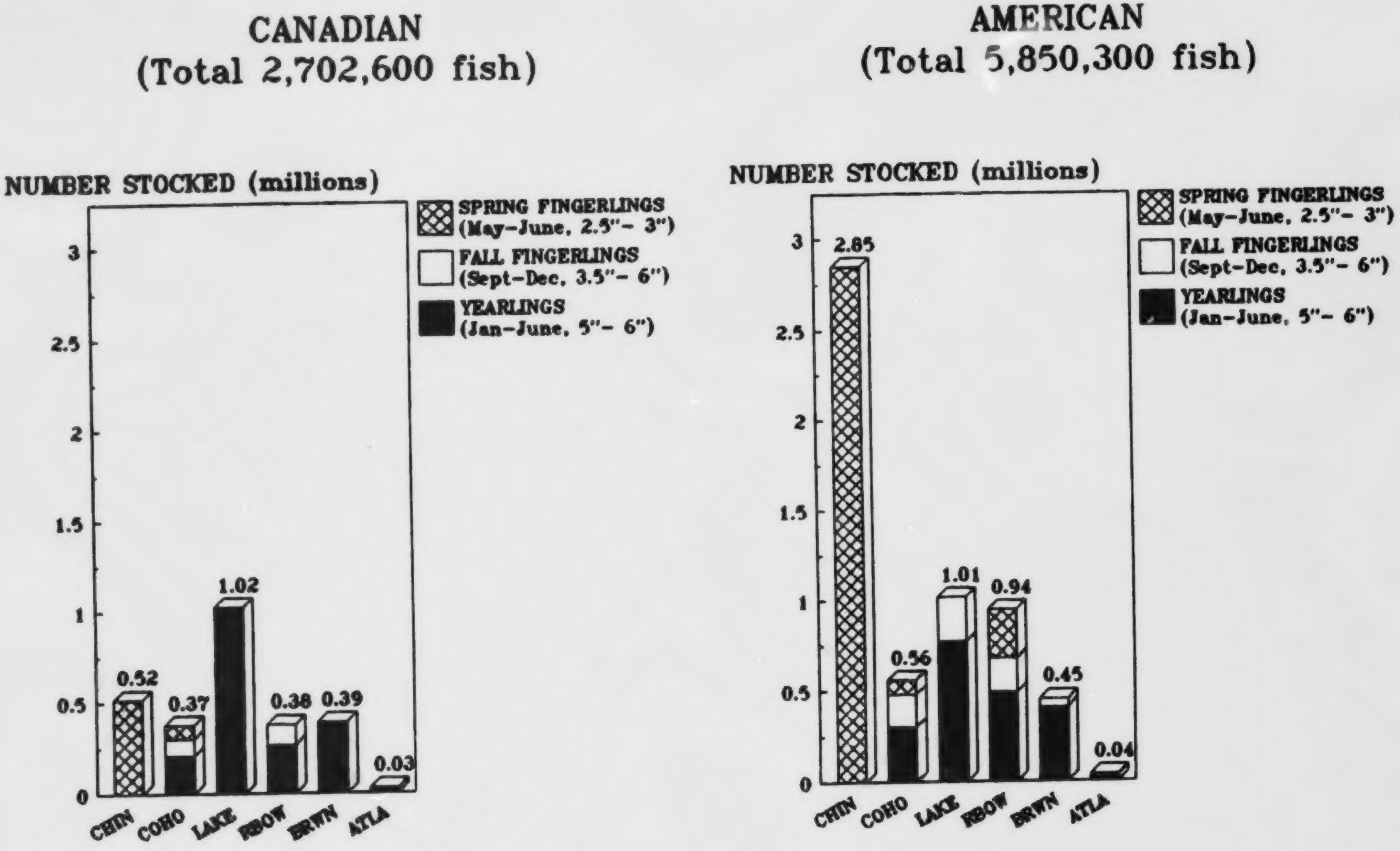


Figure 1. Lake Ontario Salmonid Species Mix Stocked By OMNR And NYDEC In 1988.



CANADIAN
(Total 2,702,600 fish)

AMERICAN
(Total 5,850,300 fish)

Figure 2. Lake Ontario Salmonid Species Mix Stocked By OMNR And NYDEC In 1988 Presented By Age Group

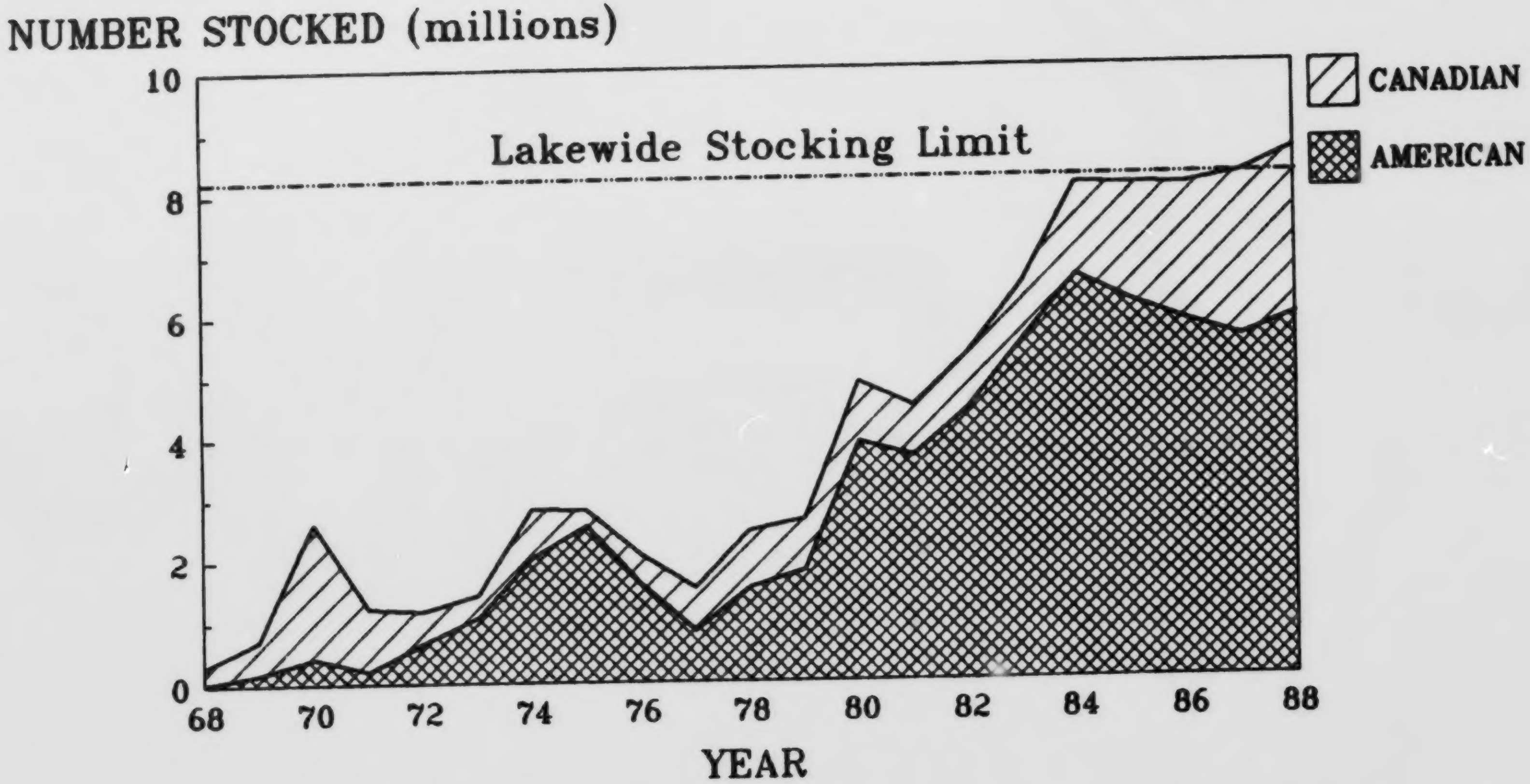


Figure 3. Lake Ontario Stocking Trends (All Species Combined) From Canadian And American Sources. Includes yearlings, all fingerlings, some fry and II+ fish. Also includes American stocked walleye beginning in 1986.

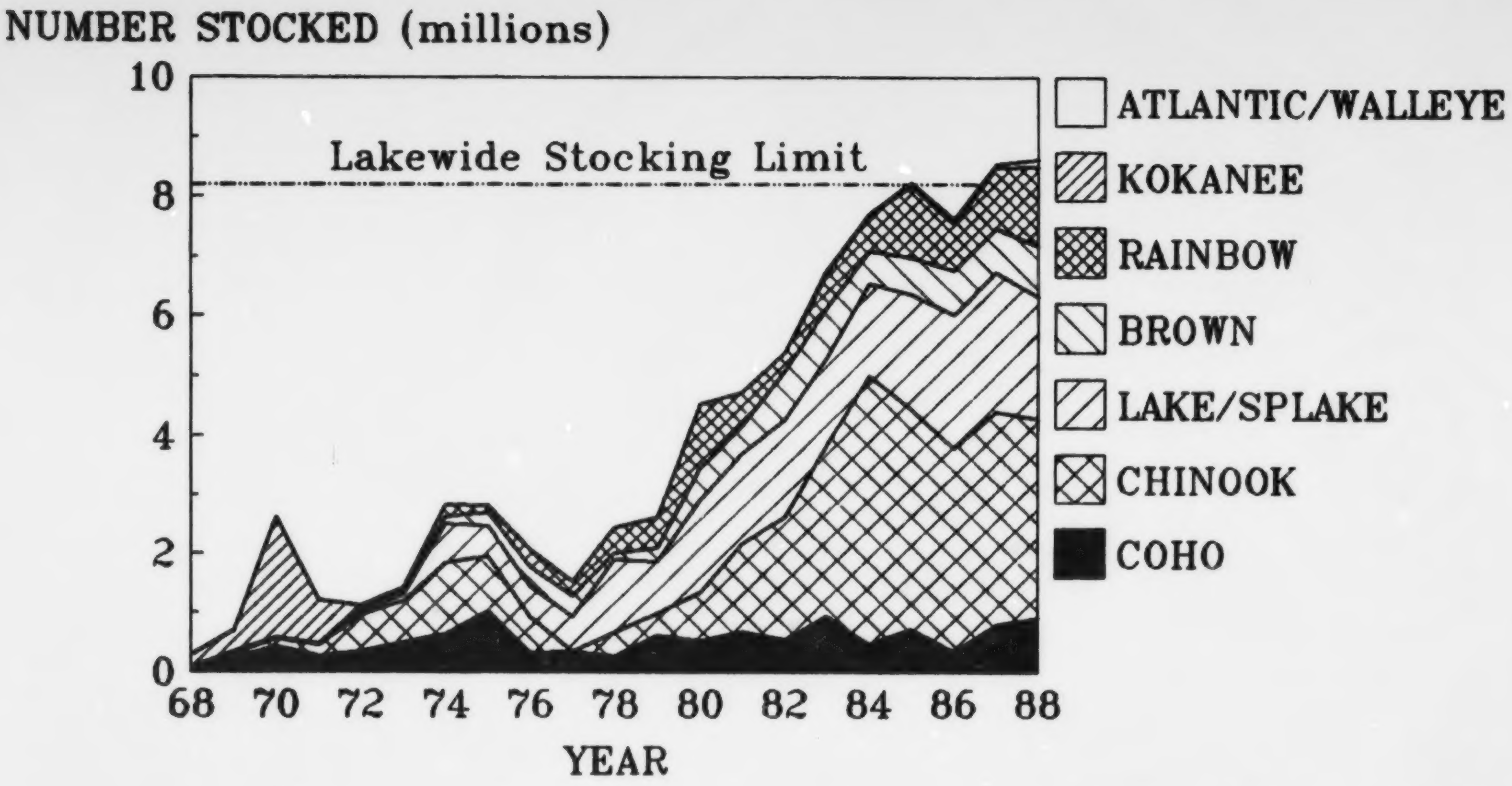


Figure 4. Lake Ontario Stocking Trends, By Species, For Combined Canadian And American Plantings. Includes all yearlings, all fingerlings, some fry and II+ fish. Canadian splake ('68-'76) are included with lake trout. U.S. also stocked 326,000 and 106,000 brook trout in '80 and '81.

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Lake Trout	Fifty Mile Point	Deer Lake	Killala Lake/ Dorion	15	36	LV	114,686
	Cobourg Harbor	Harwood	Lake Manitou	15	13	Ad-CWT	8,368
	Peter's Rock	Harwood	Killala Lake/ Dorion	15	12	Ad-CWT	107,349
	Peter's Rock	Harwood	Lake Manitou	15	13	Ad-CWT	101,054
				PETER'S ROCK TOTAL			**208,403**
	Scotch Bonnet Shoal	White Lake	Killala Lake/ Dorion	15	22	Ad-CWT	110,392
	Scotch Bonnet Shoal	White Lake	Killala Lake/ Dorion	16	34	Ad-CWT	133,457
				SCOTCH BONNET SHOAL TOTAL			**243,849**
	Main Duck Shoal	Harwood	Killala Lake/ Dorion	16	11	Ad-CWT	105,294
	Main Duck Shoal	Harwood	Lake Manitou	16	11	Ad-CWT	112,096
	Main Duck Shoal	Deer Lake	Killala Lake/ Dorion	15	32	Ad-CWT	110,784
	Main Duck Shoal	White Lake	Killala Lake/ Dorion	16	21	Ad-CWT	120,092
				MAIN DUCK TOTAL			**448,266**
				TOTAL YEARLING LAKE TROUT			**1,023,572**

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Atlantic Salmon	Credit River	Normandale	Anadromous Green Lake, Maine	13	36	Ad-RV	19,600
	Wilmot Creek	Normandale	Anadromous Green Lake, Maine	13	36	RV	7,545
				TOTAL YEARLING ATLANTIC SALMON			27,145

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Brown Trout	Rouge River	Harwood	Ganaraska/ Codrington	16	10	RP	25,324
	Ganaraska River	Codrington	Ganaraska/ Codrington	15	8	RP	5,000
	Humber River	Harwood	Ganaraska/ Codrington	16	9	RP	22,562
	12 Mile Creek (Port Dalhousie)	Harwood	Ganaraska/ Codrington	13	17	RP	5,000
	12 Mile Creek (Port Dalhousie)	Harwood	Ganaraska/ Codrington	14	19	RP	20,000
				TWELVE MILE CREEK TOTAL			25,000
	Ashbridges Bay	Harwood	Ganaraska/ Codrington	13	18	RP	25,000
	Bluffer's Park	Harwood	Ganaraska	13	18	RP	25,000
	Duffins Creek	Harwood	Ganaraska/ Codrington	14	16	RP	10,000
	Duffins Creek	Codrington	Ganaraska/ Codrington	15	10	RP	5,000
	Duffins Creek	Codrington	Ganaraska/ Codrington	16	11	RP	10,000
				DUFFINS CREEK TOTAL			25,000

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Brown Trout	Bronte Creek	Harwood	Ganaraska/ Codrington	14	16	RP	10,000
	Bronte Creek	Harwood	Ganaraska/ Codrington	16	11	RP	20,169
				BRONTE CREEK TOTAL			30,169
	Oshawa Creek	Codrington	Ganaraska/ Codrington	15	16	RP	25,000
	Fifty Mile Point	Harwood	Ganaraska/ Codrington	16	10	RP	31,666
	20 Mile Creek (Jordan Harbor)	Harwood	Ganaraska/ Codrington	13	17	RP	25,000
	Cobourg Harbor	Harwood	Ganaraska/ Codrington	16	7	RP	10,237
	Millhaven	Codrington	Ganaraska/ Codrington	15	15	RP	54,041
	Millhaven	Codrington	Ganaraska/ Codrington	16	13	RP	58,310
				MILLHAVEN YEARLING TOTAL			112,351

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Brown Trout	Millhaven	Codrington	Ganaraska/ Codrington	34-35	1	RV	171
	Millhaven	Codrington	Ganaraska/ Codrington	46-47	0.7	Ad	171
				MILLHAVEN ADULT TOTAL			**342**
				MILLHAVEN TOTAL			**112,693**
				TOTAL YEARLING BROWN TROUT			**387,309**
				TOTAL ADULT BROWN TROUT			**342**
				TOTAL BROWN TROUT			**387,651**

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Coho Salmon	Credit River	Ringwood	Lake Ontario	03	704	None	63,370
	Credit River	Ringwood	Lake Ontario	04	254	None	12,452
	Credit River	Ringwood	Lake Ontario	08	88	Ad-RP	51,977
	Credit River	Ringwood	Lake Ontario	14	19	Ad	51,935
				CREDIT RIVER TOTAL			179,734
	Bronte Creek	Ringwood	Lake Ontario	08	40	Ad-RP	12,000
	Bronte Creek	Ringwood	Lake Ontario	14	20	RV	75,004
				BRONTE CREEK TOTAL			87,004
	Port Dalhousie	Ringwood	Lake Ontario	08	41	Ad-RP	26,030
	Port Dalhousie	Ringwood	Lake Ontario	14	19	RV	80,160
				PORT DALHOUSIE TOTAL			106,190
				TOTAL SPRING FINGERLING COHO			75,822
				TOTAL FALL FINGERLING COHO			90,007
				TOTAL YEARLING COHO			207,099
				TOTAL COHO SALMON			372,928

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Chinook Salmon	Credit River	Ringwood	Lake Ontario	06	82	None	170,095
	Bronte Creek	Ringwood	Lake Ontario	06	94	None	64,453
	Hamilton Harbor	Ringwood	Lake Ontario	06	92	None	64,842
	Oshawa Creek	Ringwood	Lake Ontario	06	97	None	25,000
	Port Dalhousie	Ringwood	Lake Ontario	06	84	None	130,179
	Bowmanville Creek	Ringwood	Lake Ontario	06	97	None	26,661
	Cobourg Creek	Ringwood	Lake Ontario	06	100	None	14,977
	Cobourg Creek	Aqua-Cage Fisheries Ltd.	Lake Ontario	06	152	None	20,000
				COBOURG CREEK TOTAL			34,977
				TOTAL FINGERLING CHINOOK			516,207

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Rainbow Trout	Credit River	Normandale	Ganaraska/ Normandale	04	45	None	36,175
	Credit River	Normandale	Ganaraska/ Normandale	11	11	RV	50,030
	Credit River	Normandale	Ganaraska/ Normandale	12	10	RV	43,500
				CREDIT RIVER TOTAL			129,705
	Bronte Creek	Normandale	Ganaraska/ Normandale	04	89	None	44,200
	Bronte Creek	Deer Lake	Ganaraska/ Normandale	11	31	RV	104,410
				BRONTE CREEK TOTAL			148,610
	Rouge River	Normandale	Ganaraska/ Normandale	11	12	RV	7,200
	Rouge River	Normandale	Ganaraska/ Normandale	12	12	RV	19,000
				ROUGE RIVER TOTAL			26,200
	Duffins Creek	Normandale	Ganaraska/ Normandale	12	11	RV	40,000

Table 5. Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Rainbow Trout	Duffins Creek	Harwood	Ganaraska/ Normandale	06	70	None	30,589
				DUFFINS CREEK TOTAL			70,589
				TOTAL FALL FINGERLING RAINBOW			110,964
				TOTAL YEARLING RAINBOW			264,140
				TOTAL RAINBOW TROUT			375,104

Table 6 Page 1

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks* Applied	Number Stocked
					Lake Trout Yearlings					
Lake Ont.	Olcott	708	5/20	1987	Allegheny	Seneca	17	11.0	60-45-06	30,800
Lake Ont.	Olcott	708	5/20	1987	Allegheny	Seneca	17	11.5	60-44-50	40,000
Lake Ont.	Olcott	708	5/20	1987	Allegheny	Superior	17	12.5	60-44-44	41,000
					OLCOTT TOTAL					111,800
Lake Ont.	Hamlin	713	5/24	1987	Allegheny	Seneca	17	10.5	60-45-09	30,500
Lake Ont.	Hamlin	713	5/24	1987	Allegheny	Seneca	17	11.0	60-44-59	41,000
Lake Ont.	Hamlin	713	5/24	1987	Allegheny	Superior	17	11.0	60-44-41	41,000
Lake Ont.	Hamlin	713	5/24	1987	Allegheny	Seneca	17	11.0	60-44-49	39,200
					HAMLIN TOTAL					151,700
Lake Ont.	Sodus	818	5/19	1987	Allegheny	Seneca	17	10.4	60-45-08	30,500
Lake Ont.	Sodus	818	5/19	1987	Allegheny	Seneca	17	11.2	60-44-52	40,000
Lake Ont.	Sodus	818	5/19	1987	Allegheny	Superior	17	11.2	60-44-46	41,000
Lake Ont.	Sodus	818	5/25	1987	Allegheny	Seneca	17	13.0	60-44-51	40,000
					SODUS TOTAL					151,500

*All coded wire tagged lake trout receive an Adipose clip.

Table 6 Page 2

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks* Applied	Number Stocked
					Lake Trout Yearlings					
Lake Ont.	Selkirk	623	5/26	1987	Allegheny	Seneca	17	10.5	60-44-58	40,000
Lake Ont.	Selkirk	623	5/18	1987	Allegheny	Seneca	17	9.0	60-45-07	30,500
Lake Ont.	Selkirk	623	5/18	1987	Allegheny	Seneca	17	12.0	60-44-57	40,000
Lake Ont.	Selkirk	623	5/28	1987	Allegheny	Seneca	17	10.2	60-44-42	41,000
					SELKIRK TOTAL					151,500
Lake Ont.	Stony	422	5/17	1987	Allegheny	Ontario	17	12.0	60-44-61	39,000
Lake Ont.	Stony	422	5/17	1987	Allegheny	Seneca	17	12.3	60-44-48	40,000
Lake Ont.	Stony	422	5/17	1987	Allegheny	Jenny Lake	17	10.6	60-44-34	41,000
Lake Ont.	Stony	422	5/17	1987	Allegheny	Superior	17	11.3	60-44-45	41,000
					STONY TOTAL					161,000
Lake Ont.	Charity	422	5/17	1987	Allegheny	Ontario	17	12.0	60-44-60	40,000
					CHARITY TOTAL					40,000
					TOTAL YEARLING LAKE TROUT					767,500

*All coded wire tagged lake trout receive an Adipose clip.

Table 6 Page 3

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks* Applied	Number Stocked
					Lake Trout Fingerlings					
Lake Ont.	Olcott	708	10/17	1988	Allegheny	Superior	10	35	60-45-33	55,000
Lake Ont.	Hamlin	713	10/18	1988	Allegheny	Superior	10	35	60-45-32	55,000
Lake Ont.	Sodus	818	10/19	1988	Allegheny	Superior	10	34.4	60-45-31	55,000
Lake Ont.	Selkirk	623	10/20	1988	Allegheny	Superior	10	35.3	60-45-30	55,000
Lake Ont.	Stony	422	10/24	1988	Allegheny	Superior	10	44.9	60-45-11	27,100
					TOTAL FINGERLING LAKE TROUT					247,100
					TOTAL LAKE TROUT					1,014,600

*All coded wire tagged lake trout receive an Adipose clip.

Table 6 Page 4

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
				Atlantic Salmon Yearlings						
Irondequoit Bay	Outlet	0.18	5/5	1987	Adirondack	Little Clear	14½	10	RV-LV	17,450
Oswego River	Oswego Harbor	0.66	5/6	1987	Cortland	Penobscot	15	8	Ad-LV	470
Oswego River	Oswego Harbor	0.66	5/6	1987	Cortland	Penobscot	15	27.6	Ad-LV	6,000
Oswego River	Oswego Harbor	0.66	10/18	1987	Cortland	Penobscot	20	16.8	Ad-LV	1,280
Little Sandy Ck.	NY Route 3	0.50	5/5	1987	Adirondack	Little Clear	14½	10.4	AD	6,700
					TOTAL ATLANTIC SALMON YEARLINGS					31,900
				Atlantic Salmon Fingerlings						
Oswego Harbor		0.66	10/18	1988	Cortland	Penobscot	8	43.6	Ad-LV	5,530
					TOTAL ATLANTIC SALMON FINGERLINGS					5,530
					TOTAL ATLANTIC SALMON					37,430

Table 6 Page 5

Detailed information on salmon and trout stocked in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Brown Trout Yearlings										
Lake Ont.	Henderson Bay	423	5/3	1987	Salmon R.	Rome Lab-Randolph, Rome	15	5.1	None	16,900
Lake Ont.	Ray's Bay	523	5/4	1987	Salmon R.	Rome Lab-Randolph, Rome	15	5.1	None	17,660
Lake Ont.	Montario Pt.	523	5/3	1987	Salmon R.	Rome Lab-Randolph, Rome	15	5.1	None	17,660
Lake Ont.	Selkirk	623	5/2& 27	1987	Salmon R.	Rome Lab-Randolph, Rome	15½	5.3	None	47,280
Lake Ont.	Oswego	721	5/2	1987	Salmon R.	Rome Lab-Randolph, Rome	15	5.0	None	29,180
Lake Ont.	Fair Haven	720	4/29	1987	Rome	Rome Lab-Randolph	17	5.6	None	26,880
Lake Ont.	Sodus Point	819	4/15	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	16	4.1	None	26,100

Table 6 Page 6

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
				Brown Trout Yearlings						
Lake Ont.	Pultneyville	817	4/18	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	16	2.9	None	19,200
Lake Ont.	Webster	816	4/19	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	16	2.7	None	19,200
Lake Ont.	Irondequoit	815	4/8	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	16	3.7	None	19,200
Lake Ont.	Rochester	815	4/5	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	15½	3.4	None	24,550
Lake Ont.	Braddock's Bay	815	4/4	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	15½	4.4	None	19,200
Lake Ont.	Hamlin	713	4/1	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	15½	4.7	None	29,200

Table 6 Page 7

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Brown Trout Yearlings					
Lake Ont.	Pt. Breeze	711	4/6&7	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	15½	3.2	None	30,700
Lake Ont.	Olcott	708	4/11& 12	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	16	3.5	None	30,700
Lake Ont.	Wilson	708	4/13& 14	1987	Caledonia	Rome Lab-Randolph, Bath, Catskill	16	3.6	None	30,700
					TOTAL BROWN TROUT YEARLINGS					404,310

Table 6 Page 8

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Brown Trout Fingerlings					
Eighteen-mile Creek	Rt. 18 Bridge	0.148	6/15	1988	Catskill	Seeforellen-Catskill	3	313	None	10,010
East Branch-Twelvemile Creek	Rt. 18 Bridge	0.152	6/15	1988	Catskill	Seeforellen-Catskill	3	303	None	10,010
					TOTAL SEEFORELLEN FINGERLINGS					20,020
Oswego Harbor	Port Authority	0.66	11/3	1988	Salmon R.	Rome Lab-Randolph	10½	10.2	None	26,350
					TOTAL BROWN TROUT FINGERLINGS					46,370

Table 6 Page 9

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Coho Salmon Yearlings					
North Sandy Creek	Rt. 3 Bridge	0.44	4/12	1987	Salmon R.	Salmon R.	15	12.0	None	10,900
South Sandy Creek	Rt. 3 Bridge	0.45	4/12	1987	Salmon R.	Salmon R.	15	12.0	None	10,900
Beaverdam Brook	Smolt Release Pond	0.53-8	4/14-5/19[1]	1987	Salmon R.	Salmon R.	15½	12.0	None	90,000
Oswego River	Rt. 104 Bridge	0.66	4/8	1987	Salmon R.	Salmon R.	15	11.5	None	21,750
Sodus Bay	West Pier	0.84	4/4& 28	1987	Salmon R.	Salmon R.	15	16.0	None	30,350
Genesee River	Naval Militia Facility	0.117	4/15& 28	1987	Salmon R.	Salmon R.	15½	12.9	None	26,350
Sandy Creek	Parkway Bridge	0.130	4/8	1987	Salmon R.	Salmon R.	15	11.5	None	24,100
Oak Orchard Creek	Twin Bridges	0.138	4/5	1987	Salmon R.	Salmon R.	15	16.0	None	24,100
Eighteenmile Creek	Olcott Harbor	0.148	4/5& 28	1987	Salmon R.	Salmon R.	15	16.0	None	32,550
Niagara River	Lewiston Sand Docks	0.158	4/15& 28	1987	Salmon R.	Salmon R.	15½	12.9	None	28,850
					TOTAL COHO SALMON YEARLINGS					299,850

[1] The fish were stocked in the hatchery smolt release pond on April 14 and allowed to voluntary migrate until 5/19 when the pond was drained. Approx. ½ migrated voluntarily prior to 5/19.

Table 6 Page 10

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Coho Salmon Fingerlings					
Lake Ont.	Rochester	815	6/10	1988	Salmon R.	Salmon R.	5½	125	None	40,000
Niagara R.	Lewiston Sand Docks	0.158	6/10	1988	Salmon R.	Salmon R.	5½	125	None	40,000
					TOTAL COHO SALMON SURPLUS SPRING FINGERLINGS					80,000
Lake Ont.	Ray's Bay	523	11/16	1988	Caledonia	Salmon R.	11	18.0	None	32,000
Oswego R.	Port Authority	0.66	11/18	1988	Caledonia	Salmon R.	11	17.0	None	18,800
Sodus Bay	West Pier	0.84	11/14	1988	Caledonia	Salmon R.	10½	12.6	None	22,000
Genesee R.	Naval Militia Facility	0.117	11/4	1988	Caledonia	Salmon R.	10½	12.6	None	18,400
Sandy Ck.	Parkway Bridge	0.130	11/3	1988	Caledonia	Salmon R.	10½	14.2	None	22,000
Oak Orchard Creek	Twin Bridges	0.138	11/2	1988	Caledonia	Salmon R.	10½	12.0	None	22,000
Eighteenmile Creek	Olcott Harbor	0.148	11/3	1988	Caledonia	Salmon R.	10½	14.2	None	22,000
Niagara R.	Lewiston Sand Docks	0.158	11/2	1988	Caledonia	Salmon R.	10½	12.5	None	19,200
					TOTAL COHO SALMON FALL FINGERLINGS					176,400

Table 6 Page 11

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Chinook Salmon Fingerlings					
Black River	Dexter boat launch	0.19	5/27	1988	Salmon R.	Salmon R.	4	101	None	70,000
Henderson Bay	Association Island Cut	423	5/26	1988	Salmon R.	Salmon R.	4	75	LV-CWT (23-16-1)	41,400
Henderson Bay	Association Island Cut	423	5/26	1988	Salmon R.	Salmon R.	4	75	None	18,600
					ASSOCIATION ISLAND CUT TOTAL					60,000
Lake Ont.	Southwick Beach St. Pk.	523	5/27	1988	Salmon R.	Salmon R.	4	75	LV-CWT (23-16-3)	41,100
Lake Ont.	Southwick Beach St. Pk.	523	5/27	1988	Salmon R.	Salmon R.	4	75	None	18,900
					SOUTHWICK BEACH STATE PARK TOTAL					60,000
N. Sandy Creek	NY Rt 3	0.44	5/19	1988	Salmon R.	Salmon R.	4	120	None	90,000
S. Sandy Creek	NY Rt 3	0.45	5/19	1988	Salmon R.	Salmon R.	4	120	None	90,000

Table 6 Page 12

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Chinook Salmon Fingerlings					
Beaverdam Brook	Salmon River Hatchery	0.53-8	5/27	1988	Salmon R.	Salmon R.	4	75	LV-CWT (23-16-2)	41,200
Beaverdam Brook	Salmon River Hatchery	0.53-8	6/3	1988	Salmon R.	Salmon R.	5	88	None	543,800
					BEAVERDAM BROOK TOTAL					585,000
Oswego R.	Oswego Harbor	0.66	5/25	1988	Salmon R.	Salmon R.	4	105	None	225,000
Oswego R.	Oswego Harbor	0.66	5/31	1988	Salmon R.	Salmon R.	4	95	None	40,000*
					OSWEGO RIVER TOTAL					265,000
Little Sodus Bay	Fair Haven State Park	0.74	5/18, 24,31	1988	Salmon R.	Salmon R.	4	109	None	180,000
Sodus Bay	Outlet Channel	0.84	5/12, 26	1988	Salmon R.	Salmon R.	4	113	None	180,000
Genesee R.	Old Naval Militia	0.117	5/13	1988	Caledonia	Salmon R.	4	108	None	274,000
Genesee R.	Old Naval Militia	0.117	5/31	1988	Salmon R.	Salmon R.	4	95	None	40,000*
					GENESEE RIVER TOTAL					314,000

*Indicates surplus stocking

Table 6 Page 13

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Chinook Salmon Fingerlings										
Sandy Ck.	DEC Boat Launch	0.130	5/27	1988	Salmon R.	Salmon R.	4	100	None	200,000
Oak Orchard Creek	Twin Bridges	0.138	5/12	1988	Caledonia	Salmon R.	4	94	None	269,000
Eighteenmile Creek	Olcott Harbor	0.148	5/26	1988	Salmon R.	Salmon R.	4	112	None	180,000
Twelvemile Creek	Wilson Harbor	0.152	5/27	1988	Salmon R.	Salmon R.	4	100	None	80,000
Niagara R.	Lewiston Sand Docks	0.158	5/23	1988	Salmon R.	Salmon R.	4	118	None	225,000
					TOTAL CHINOOK SALMON FINGERLINGS					2,848,000

Table 6 Page 14

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Rainbow Trout Yearlings					
Lake Ont.	Henderson Harbor	423	5/11	1987	Caledonia	Nashua	13	3.7	None	16,830
Lake Ont.	Selkirk Shores State Park	623	5/10	1987	Caledonia	Nashua	13	4.0	None	16,830
Lake Ont.	Sodus Point	819	5/9	1987	Caledonia	Nashua	13	3.6	None	13,450
Lake Ont.	Hamlin Beach State Park	713	5/3,6	1987	Caledonia	Nashua	13	2.8	None	13,460
Lake Ont.	Olcott Harbor	708	5/2,3	1987	Caledonia	Nashua	13	2.7	None	8,400
Lake Ont.	Wilson Harbor	707	5/3	1987	Caledonia	Nashua	13	2.6	None	8,400
					TOTAL RAINBOW YEARLINGS					77,370

Table 6 Page 15

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Rainbow Trout Fingerlings					
Lake Ont.	Port Bay	819	10/13	1988	Caledonia	Nashua	6	13.8	None	21,000*
Lake Ont.	Irondequoit	815	10/26	1988	Caledonia	Nashua	6	13.0	None	23,500*
Lake Ont.	Hamlin Beach State Park	713	9/27	1988	Caledonia	Nashua	6	14.7	None	23,000
Lake Ont.	Hamlin Beach State Park	713	10/14	1988	Caledonia	Nashua	6	13.5	None	21,000*
Lake Ont.	Oak Orchard Creek	0.138	10/21	1988	Caledonia	Nashua	6	14.0	None	42,000*
Niagara R.	Lewiston	0.158	9/30	1988	Caledonia	Nashua	6	17.6	None	20,000*
					TOTAL SCHEDULED RAINBOW FINGERLINGS					23,000
					TOTAL SURPLUS RAINBOW FINGERLINGS					127,500
					TOTAL RAINBOW FINGERLINGS					150,500

*Indicates surplus stocking

Table 6 Page 16

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Steelhead Trout Yearlings					
Black River	Dexter	0.19	4/12	1987	Salmon R.	Washington-Salmon River	11	19.3	None	18,900
Stony Ck.	At NY Rt. 3	0.40	4/20	1987	Caledonia	Skamania	12	8.0	Ad-LP	18,000
South Sandy Ck.	Below NY Rt. 3	0.45	4/12	1987	Salmon R.	Washington-Salmon River	11	19.3	None	23,600
Salmon River	Beaverdam Bk. at Salmon R. Hatchery	0.53-8	5/19	1987	Salmon R.	Washington-Salmon River	12	12.0	LV	90,000
Salmon R.	At Pineville Bridge	0.53	4/12	1987	Salmon R.	Washington-Salmon River	11	14.8	LV	4,700
Salmon R.	At Co. Rt. 2A	0.53	4/12	1987	Salmon R.	Washington-Salmon River	11	14.8	LV	4,700
Salmon R.	Spring Bk. Reservoir	0.53-2-P.6	4/12	1987	Salmon R.	Washington-Salmon River	11	14.8	LV	9,400
Salmon R.	Orwell Brook lower 3 bridges	0.53-6	4/12	1987	Salmon R.	Washington-Salmon River	11	14.8	LV	9,400
					SALMON RIVER TOTAL					118,200

Table 6 Page 17

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Steelhead Trout Yearlings					
Lake Ont.	Selkirk Shores State Park	623	5/23	1987	Bath	Finger Lakes wild/Nashua hybrid	11	7.6	None	6,780*
Catfish Ck.	Co. Rt. 1	0.60	4/12	1987	Caledonia	Skamania	12	8.2	Ad-LP	10,000
Oswego R.	Oswego Harbor	0.66	3/31	1987	Caledonia	Washington-Salmon River	10	7.3	LV	14,200
Oswego R.	Oswego Harbor	0.66	3/31	1987	Caledonia	Skamania	12	8.4	Ad-LP	18,000
					OSWEGO RIVER TOTAL					**32,200**
Maxwell Ck.	Rt. 18 bridge	0.85	4/14	1987	Caledonia	Skamania	12	7.8	ADLP	18,000
Irondequoit Creek	above Powdermill Park	0.108	4/25	1987	Caledonia	Washington-Salmon River	11	6.4	None	12,000
Irondequoit Creek	Landing Rd.	0.108	4/29	1987	Caledonia	Washington-Salmon River	11	5.9	None	11,600
					IRONDEQUOIT CREEK TOTAL					**23,600**
Genesee R.	Old Naval Militia	0.117	4/8	1987	Caledonia	Washington-Salmon River	10	8.2	LV	18,900
Salmon Ck.	lower portion	0.125	4/6	1987	Caledonia	Washington-Salmon River	10	8.2	LV	9,400

*Indicates surplus stocking

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Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Steelhead Trout Yearlings					
Sandy Ck.	below Rt. 18	0.130	4/24	1987	Caledonia	Washington-Salmon River	11	6.4	None	12,500
Oak Orchard Ck.	Twin Bridges	0.138	4/29	1987	Caledonia	Washington-Salmon River	11	6.2	None	18,900
Keg Ck.	Rt. 18 Bridge	0.148	4/5	1987	Caledonia	Washington-Salmon River	10	7.6	LV	10,500
E. Branch Twelvemile Creek	Rt. 18 Bridge	0.152	4/7	1987	Caledonia	Skamania	12	8.2	Ad-LP	12,500
Twelvemile Creek	Rt. 18 Bridge	0.152A	4/4	1987	Caledonia	Skamania	12	7.9	Ad-LP	12,500
Niagara R.	Lewiston Sand Docks	0.158	4/22	1987	Caledonia	Skamania	12	7.8	Ad-LP	18,000
Niagara R.	Joseph Davis Park	0.158	4/26, 27	1987	Caledonia	Washington-Salmon River	11	6.1	LV	25,000
					NIAGARA RIVER TOTAL					43,000
					TOTAL WASHINGTON STEELHEAD					293,700
					TOTAL SKAMANIA STEELHEAD					107,000
					TOTAL FINGER LAKES WILD X DOMESTIC					6,780
					TOTAL YEARLING STEELHEAD					407,480

Table 6 Page 19

Detailed information on salmon and trout stocked in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
					Steelhead Trout Fingerlings					
Grindstone Creek	Fernwood and downstream	0.54	10/21	1988	Bath	Finger Lakes Wild	4	319	None	38,600*
Grindstone Creek	Fernwood and downstream	0.54	6/29	1988	Salmon R.	Washington-Salmon River	1	750	None	100,000*
					GRINDSTONE CREEK TOTAL					**138,600**
Niagara R.	Lewiston Sand Dock	0.158	7/14	1988	Salmon R.	Washington-Salmon River	1	520	None	78,500*
Lake Ont.	White's Bay	424	7/15	1988	Salmon R.	Washington-Salmon River	1	500	None	90,950*
					TOTAL SURPLUS STEELHEAD FINGERLING					**308,050**

*Indicates surplus stocking

Table 6 Page 20

Detailed information on salmon and trout stocked
in New York Lake Ontario waters in 1988

Area Stocked	Location	Grid/ Key	Approx. Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	Size	Marks Applied	Number Stocked
					Walleye Fingerlings					
Niagara R.	Lewiston	0.158	7/1	1988	NRAA1/ Ponds	Constantia	4	2½	None	29,580
Lake Ont.	Lewiston	0.158	7/1	1988	NRAA Ponds	Constantia	4	3& 3/4"-14"	RP	170
Lake Ont.	Little Sodus Bay	720	7/1	1988	Sanford Bait Farms2/	Constantia	4	1½-2"	None	14,000
Lake Ont.	Port Bay	819	7/1	1988	Sanford Bait Farms	Constantia	4	2"	None	15,000
Lake Ont.	Port Bay	819	10/1	1988	Sanford Bait Farms	Constantia	7	3"-10"	None	500
Lake Ont.	Little Sodus Bay	720	7/1	1988	Sanford Bait Farms	Constantia	4	3"	None	4,200
						TOTAL WALLEYE FINGERLINGS				63,450

1/ Niagara River Anglers Association - 8 ponds, ½ acre each

2/ Sanford Bait Farms - 3 ponds, ½ acre each

Table 7. Important deviations from the proposed stocking numbers by OMNR and DEC in 1988.

Species	Agency	Number (in thousands)	Reason
Lake trout	DEC	-252Y +67F	Attempting to reach our goal of 1,020,000 yearling and 180,000 fingerlings.
Coho	DEC	-50Y +176F +80f	Yearling shortage due to reduced egg take, spring fingerlings were all excess, and fall fingerlings were sorted and large individuals were stocked.
	OMNR	+47Y +86F	Due to experimental stocking of fall fingerlings, stocking of surplus spring fingerlings and good yearling survival.
Steelhead	DEC	+308F	Excellent survival, fingerlings stocked to create hatchery space.
Rainbow trout	DEC	-38Y +127F	Yearling shortage is caused by lack of hatchery space, fingerling excess stocked to make space.
	OMNR	+89Y +111F	Better than anticipated survival.
Brown trout	DEC	-96Y +46F	Statewide shortage of yearlings and stocking of fingerlings to create hatchery space.
	OMNR	-48Y	Hatchery shortfall
Atlantic salmon	DEC	-17Y	Hatchery modernization caused reduced space.
	OMNR	-23Y	Shortfall in egg supply of landlocked strain.

Legend:
Y: Yearlings, stocked between January and June, usually 5" to 9"
F: Fall fingerlings, stocked between September and December usually 3½" to 6"
f: Spring fingerlings, stocked May and June usually 2½" to 3"

Table 8. Proposed 1989 stocking in Province of Ontario waters of Lake Ontario.

Species	Location	Quantity	Age
Coho salmon	Credit River	100,000	Yearling
	Bronte Creek	30,000	Yearling
	Martindale Pond	30,000	Yearling
	Credit River	50,000	Fall Fingerling
	Bronte Creek	10,000	Fall Fingerling
	Martindale Pond	20,000	Fall Fingerling
		240,000	
Chinook salmon	Credit River	200,000	Spring Fingerling
	Hamilton Harbor	75,000	Spring Fingerling
	Bronte Creek	75,000	Spring Fingerling
	Niagara Area	150,000	Spring Fingerling
	Cobourg Area	40,000	Spring Fingerling
	Oshawa Creek	30,000	Spring Fingerling
	Bowmanville Creek	30,000	Spring Fingerling
	Northumberland	50,000	Spring Fingerling
		650,000	
Brown trout	12 Mile Creek	35,000	Yearling
	Jordan Harbor	35,000	Yearling
	Collins Bay	55,000	Yearling
	Parrott's Bay	55,000	Yearling
	Bronte Creek	35,000	Yearling
	50 Mile Point	35,000	Yearling
	Ganaraska River	15,000	Yearling
	Oshawa Creek	25,000	Yearling
	Cobourg Area	10,000	Yearling
	Humber River	35,000	Yearling
	Rouge River	25,000	Yearling
	Duffins Creek	25,000	Yearling
	Toronto Island	25,000	Yearling
	Bluffer's Park	25,000	Yearling
		435,000	
Lake trout	50 Mile Point	200,000	Yearling
	Port Hope	200,000	Yearling
	Scotch Bonnet Shoal	250,000	Yearling
	Charity-Main Duck Sh.	500,000	Yearling
		1,150,000	
Rainbow trout	Credit River	100,000	Yearling
	Bronte Creek	75,000	Yearling
		175,000	
Atlantic salmon	Credit River	40,000	Yearling
	Wilmot Creek	10,000	Yearling
		50,000	
	CANADIAN TOTAL ALL SPECIES	2,700,000	

Table 9. Proposed 1989 stocking of New York waters in Lake Ontario

REGION	LOCATION	KEY	NUMBER	AGE
		CHINOOK SALMON		
6	Association Island	423	180,000	4 months
6	North Sandy Creek	0.45	90,000	4 months
6	South Sandy Creek	0.45	90,000	4 months
7	Salmon River	0.53	300,000	4 months
7	Lower Salmon River	0.53	270,000	4 months
7	Oswego River	0.66	225,000	4 months
7	Little Sodus Bay	0.73	180,000	4 months
8	Sodus Bay	0.84	180,000	4 months
8	Genesee River	0.117	270,000	4 months
8	Sandy Creek	0.130	180,000	4 months
8	Oak Orchard Creek	0.138	270,000	4 months
9	Eighteenmile Creek	0.148	180,000	4 months
9	Twelvemile Creek	0.152	60,000	4 months
9	Lower Niagara River	0.157	225,000	4 months
		TOTAL	2,700,000	
		COHO SALMON		
6	Black River	0.19	30,000	Yearling
6	North Sandy Creek	0.45	15,000	Yearling
6	S. Sandy Creek	0.45	15,000	Yearling
7	Salmon River	0.53	90,000	Yearling
7	Oswego River	0.66	30,000	Yearling
8	Sodus Creek	0.84	30,000	Yearling
8	Genesee River	0.117	25,000	Yearling
8	Sandy Creek	0.130	30,000	Yearling
8	Oak Orchard Creek	0.138	30,000	Yearling
9	Eighteenmile Creek	0.148	30,000	Yearling
9	Niagara River	0.157	25,000	Yearling
		TOTAL	350,000	
		ATLANTIC SALMON		
6	Lindsey Creek	0.48	11,000	Yearling
7	Little Sandy Creek	0.50	20,000	Yearling
8	Irondequoit Creek	0.108	18,000	Yearling
		TOTAL	49,000	

Table 9. Proposed 1989 stocking of New York waters in Lake Ontario

REGION	LOCATION	KEY	NUMBER	AGE
		BROWN TROUT		
6	Ray Bay	523	38,000	Yearling
6	Henderson Bay	424	30,000	Yearling
7	Fairhaven Beach St. Pk.	720	35,000	Yearling
7	Oswego Harbor	721	38,000	Yearling
7	Selkirk Shores St. Pk.	623	35,000	Yearling
8	Hamlin Beach St. Pk.	713	38,000	Yearling
8	Irondequoit	815	25,000	Yearling
8	Genesee River	815	32,000	Yearling
8	Braddocks	815	25,000	Yearling
8	Webster	816	25,000	Yearling
8	Point Breeze	711	40,000	Yearling
8	Sodus	819	34,000	Yearling
8	Pultneyville	817	25,000	Yearling
9	Wilson	707	40,000	Yearling
9	Olcott	708	40,000	Yearling
		TOTAL	500,000	
		LAKE TROUT		
6	Dablon Point	322-323	120,000	Yearling
6	Dablon Point	322-323	50,000	Yearling
6	Stony Point	422-423	120,000	Yearling
6	Stony Point	422-423	50,000	Yearling
6	Stony Point	422-423	60,000	Fingerling
7	Selkirk	623	120,000	Yearling
7	Selkirk	623	50,000	Yearling
7	Selkirk	623	30,000	Fingerling
8	Hamlin Beach	713	120,000	Yearling
8	Hamlin Beach	713	50,000	Yearling
8	Hamlin Beach	713	30,000	Fingerling
8	Sodus	819	120,000	Yearling
8	Sodus	819	50,000	Yearling
8	Sodus	819	30,000	Fingerling
9	Niagara	806	120,000	Yearling
9	Niagara	806	50,000	Yearling
9	Niagara	806	30,000	Fingerling
		TOTAL	1,020,000	Yearling
			180,000	Fingerling

Table 9. Proposed 1989 stocking of New York waters in Lake Ontario

REGION	LOCATION	KEY	NUMBER	AGE
		WASHINGTON STEELHEAD		
6	Black River	0.19	20,000	Yearling
6	South Sandy Creek	0.45	25,000	Yearling
7	Salmon River	0.53	120,000	Yearling
7	Oswego River	0.66	15,000	Yearling
8	Genesee River	0.117	20,000	Yearling
8	Irondequoit Creek	0.108	24,000	Yearling
8	Salmon Creek	0.125	10,000	Yearling
8	Sandy Creek	0.130	13,300	Yearling
8	Oak Orchard Creek	0.138	20,000	Yearling
9	Keg Creek	0.146	11,100	Yearling
9	E. Br. Twelvemile Ck.	0.152	13,300	Yearling
9	Twelvemile Creek	0.152A	13,300	Yearling
9	Lower Niagara River	0.157	25,000	Yearling
		TOTAL	330,000	
		SKAMANIA STEELHEAD		
6	Stony Creek	0.40	18,000	Yearling
7	Catfish Creek	0.60	10,000	Yearling
7	Oswego River	0.66	18,000	Yearling
8	Maxwell creek	0.85	18,000	Yearling
9	Niagara River	0.157	18,000	Yearling
		TOTAL	82,000	
		DOMESTIC RAINBOW TROUT		
6	Henderson Bay	424	25,000	Yearling
7	Selkirk Shores St. Pk.	623	25,000	Yearling
8	Hamlin Beach St. Pk.	713	20,000	Yearling
8	Hamlin Beach St. Pk.	713	23,000	Fingerling
8	Sodus	819	20,000	Yearling
9	Wilson	707	12,500	Yearling
9	Olcott	708	12,500	Yearling
		TOTAL	115,000	Yearling
			23,000	Fingerling

Great Lakes Fishery Commission
Lake Ontario Committee Meeting
March 21-22, 1989
Buffalo, New York

SMELT ABUNDANCE AND GROWTH IN WESTERN LAKE ONTARIO

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ABSTRACT

The abundance of smelt in western Lake Ontario over the years 1981-1988 is estimated at between 0.4 and 1.9 billion. Annual abundances are highly correlated with those determined for U.S. waters, but densities are approximately 5 times greater in western Lake Ontario. Cyclical recruitment of yearling smelt, attributed to cannibalism, likely accounts for a strong periodicity in annual abundance. Growth of age I-II smelt is faster in western Lake Ontario. Size of older age groups, while similar in both areas of Lake Ontario, has declined in recent years. An observed decrease in abundance of larger smelt is likely due to the decline in growth.

RECOMMENDATIONS

1. Continue to use bottom trawls to monitor smelt on both sides of the border.

2. Continue to develop forage fish stock assessment techniques for central Lake Ontario (Toronto to Brighton).

3. Analyze existing research bottom trawl and gillnet data series for the Eastern Outlet Basin of Lake Ontario.

4. Collaborate with American biologists to comprehensively describe the abundance, distribution and growth of smelt in southern and western Lake Ontario. Specifically, reconcile differences in methodology such as ageing and depth stratification, confirm the observed differences in growth and abundance, and determine if the abundances of older age groups have declined in recent years.

5. Compare both nutrient levels and plankton biomass between the U.S. side and western Lake Ontario to determine if the faster growth observed in young western Lake Ontario smelt is due to higher availability of food resources.

6. Review data from OMNR salmonid diet surveys done in 1983-85 to:
   a) determine whether predation of salmonids on smelt is size selective and
   b) test the hypothesis that salmonid predation on smelt increased in 1984 when the abundance of large alewife was reduced.

7. Implement salmonid diet surveys in conjunction with western Lake Ontario bottom trawling in 1989.

INTRODUCTION

Rainbow smelt (Osmerus mordax) first entered the Lake Ontario fishery in the 1940's and soon formed the basis of a large recreational fishery (Christie 1972). Smelt may not have been heavily preyed upon by salmonids until after lamprey control programs were implemented and salmonid stocking was increased dramatically beginning in the late 1970's. Wismer (1983) reported that in western Lake Ontario, smelt were the second most important prey item of salmonids. They were found in an average of 11% of the diets of rainbow trout, chinook salmon, coho, lake trout and brown trout. Effective and ecologically sound management of the Lake Ontario fisheries resource requires that the status of smelt stocks be assessed.

In 1978 the U.S. Fish and Wildlife Service (USFWS) initiated a spring bottom trawl sampling program to assess the abundance of smelt and alewife in U.S. waters (O'Gorman et al. 1988). Beginning in 1981, smelt were sampled from bottom trawls in Canadian waters during juvenile lake trout assessment (Elrod et al. 1986) conducted jointly in August by the USFWS, the New York Department of Environmental Conservation (NYDEC), and the Ontario Ministry of Natural Resources (OMNR). Cooperative spring (June) bottom trawling for smelt in Canadian waters, independent of the juvenile lake trout assessment, began in 1986. The purposes of this preliminary report are to describe abundance, size and growth of smelt in Canadian waters of western Lake Ontario, compare these data to published information from the U.S. bottom trawling from 1981-88, and suggest future investigations and management directions.

METHODS

FISH SAMPLING AND ABUNDANCE CALCULATIONS

In early August of 1981-85 the USFWS Research Vessel Kaho bottom trawled along three principal transects in western Lake Ontario; Niagara, Hamilton, and Toronto (Fig. 1). At each site, trawling was done at 5 m depth intervals starting at 15-20 m to a maximum of 55 m. From 1986-88 sampling was conducted in June at approximately the same locations with the addition of an 8 m site and several sites deeper than 55 m. To accommodate differences in sampling depths among years, we derived estimates of abundance for bottom areas common to all years surveyed (10-50 m). Catches were stratified into bottom areas of 10-20, 20-30, 30-40 and 40-50 m. Each year's abundance was the summation over all areas of the average catch/10-minute tow in each depth stratum times the number of hectares in each stratum, multiplied by two. Multiplying by two assumes that a 10-minute tow of the bottom trawl sweeps an area of approximately 0.5 hectares (NYDEC/USFWS MS.) Our data suggest that most smelt are captured over bottom areas at depths of 10-50 m, providing the basis for preliminary comparison to U.S. data.

A severe storm during the western Lake Ontario trawling in 1983 curtailed sampling of some sites, caused partial thermal destratification, and drastically altered local smelt distributions. Therefore the 1983 western Ontario data were ignored when comparing with U.S. smelt values.

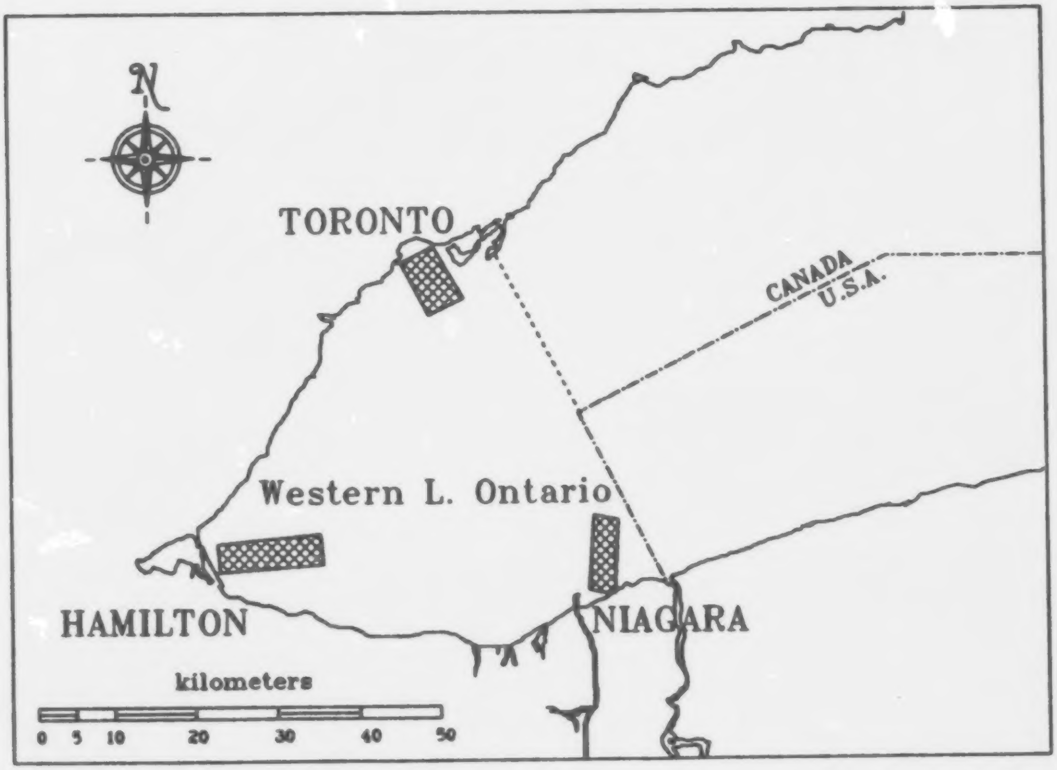

Figure 1. Map of western Lake Ontario. Bottom trawls were taken within cross-hatched areas.

AGE COMPOSITION AND GROWTH OF SMELT

A random sample of smelt were measured for length from each depth contour sampled. Length, weight, sex, and ageing material were taken from a length stratified subsample of approximately 200-400 individuals per year. Fish were aged by scales from 1981-85, and from pectoral fin ray sections from 1986-88. A few small fish on which no annuli were discernible were classed as age I if they were less than 92.5 mm fork length. Based on length frequency distributions of aged samples, this was the length that most accurately and conservatively separated age I from age II fish.

Population length frequency distributions were derived by combining length samples, weighted by catch per unit effort, from all catches. The proportion of each age group in the population was estimated using the method of Hoenig and Heisey (1987). This method finds the maximum likelihood estimates of population age composition from sample length frequency distribution of individual age groups. Traditionally, age compositions are determined from length frequencies and age-length keys. An age-length key is simply the distribution of ages within length classes. The method of Hoenig and Heisy (1987) uses an inverse age-length key which is the distribution of lengths within an age group. The advantage of this approach is that an inverse age-length key from one year can be applied to population length frequencies from other years to estimate age composition. The only assumptions required are that growth and gear selectivity do not change from year to year. We were able to take advantage of this feature in the absence of corresponding age data and apply it to the 1984 and 1988 population length frequencies. We estimated the 1984 age composition using a combined 1983 and 1985 age-length key, and estimated the 1988 age composition from the 1987 age-length key. For these applications, the assumption of constant growth and gear selectivity are reasonable.

To examine growth of smelt, mean total lengths of age classes through time were plotted. Trends were compared graphically between western Ontario and U.S. waters.

RESULTS

ABUNDANCE OF SMELT IN U.S. VS. WESTERN LAKE ONTARIO WATERS

Abundance of smelt in western Lake Ontario fluctuates considerably from year to year but is estimated at between 0.4 and 1.9 billion individuals (Fig. 2). With one exception, the total abundance peaks and falls on alternate years. Similar patterns were reported by American workers (O'Gorman et al. 1983, 1985, 1988), and western Lake Ontario abundances correlate significantly with U.S. values through time (Spearman rank correlation $r = 0.94$, $p<0.05$; Fig. 2).

There is some indication of an increase in western Lake Ontario smelt abundance through time (Fig. 2). This trend is complicated by the periodicity and is not significant ($p>0.05$, Spearman rank correlation).

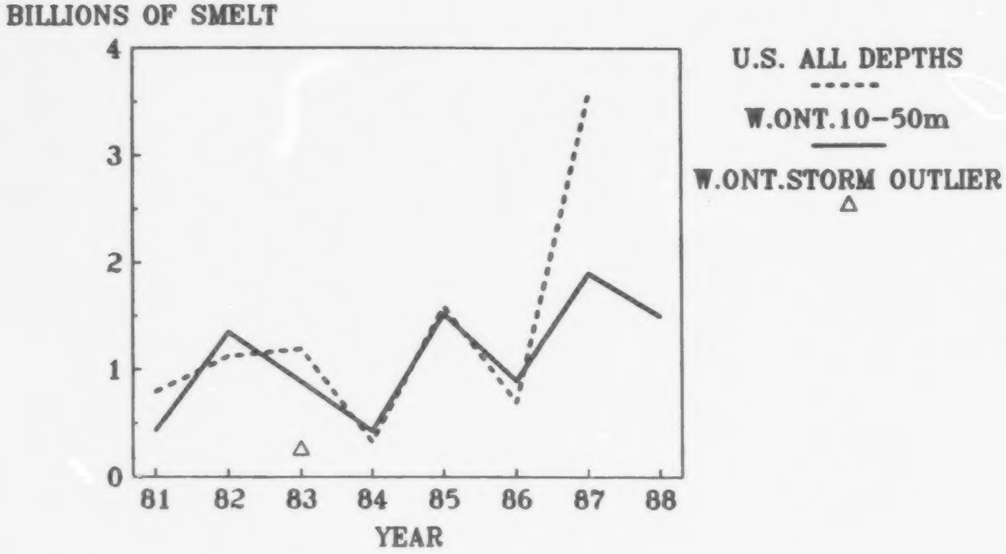

Figure 2. Abundances of smelt available to bottom trawls in western Lake Ontario areas of 10-50 m depth and in U.S. waters of all depths. U.S. data from O'Gorman et al. (1988).

Cyclical recruitment of yearling smelt in western Lake Ontario accounts for the observed periodicity in overall abundance. During years of high abundance, the proportion of yearling smelt was 63 to 88% of the total population sampled. Yearling smelt abundance in western Lake Ontario is strongly correlated with yearling abundance reported in U.S. waters (Fig. 3; $p < 0.05$, Spearman rank correlation). These data agree with the suggestion that a strong year-class is followed by a weak year-class one or two years later, when the strong year-class heavily cannibalizes young-of-the-year (Regier et al. 1969 in O'Gorman et al. 1983).

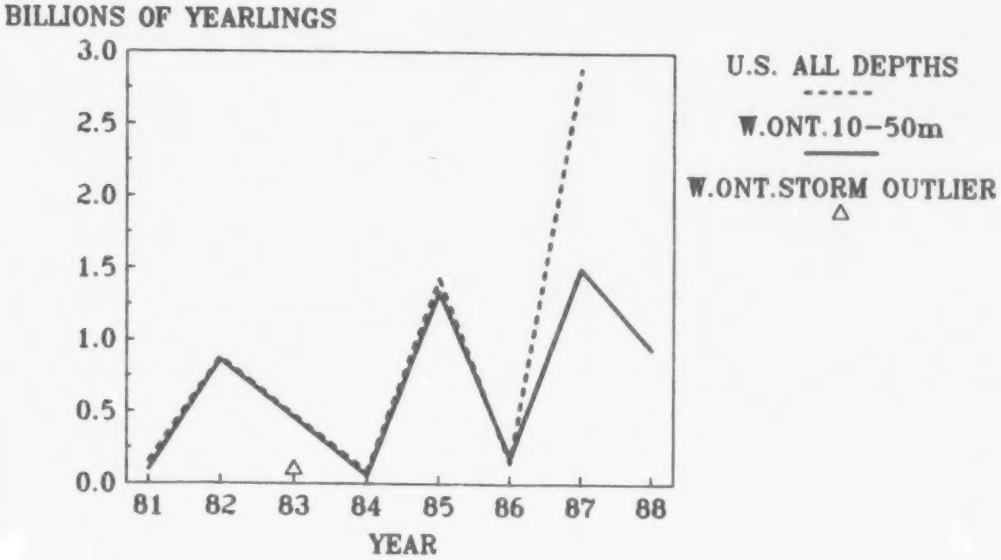

Figure 3. Abundance of yearling smelt available to bottom trawls. Western Lake Ontario 1984 and 1988 data are estimated from length at age distributions in proximate years. U.S. data from O'Gorman et al. (1988).

GROWTH OF SMELT

Growth of young smelt in western Lake Ontario may be higher than in U.S. waters. In recent years, mean length-at-age of yearlings and age II's appear to be greater in western Ontario than on the U.S. side (Fig. 4). Statistical comparisons were not possible with available published information, but differences in mean size generally exceed the 95 % confidence interval for western Ontario smelt (Fig. 4).

With available data, it is difficult to discern any major differences between western Lake Ontario and U.S. smelt lengths-at-age of older year classes (Fig. 5). Thus the size advantage of young western Ontario smelt does not appear to be conferred on older fish.

Both the western and U.S. data sets show a trend to reduced growth of older smelt (ages IV-V) in recent years. In conjunction with this trend, the proportion of large smelt in bottom trawl catches has decreased over the last several years (Fig. 6). Western Lake Ontario trawl catches in the 150 mm length class or greater went from about 15% in the early 80's to about 2% in the latter part of the decade (Fig. 6). This decrease parallels the decline in length-at-age of age IV and V fish, and confirms the decrease in abundance of large smelt observed by O'Gorman et al. (1988).

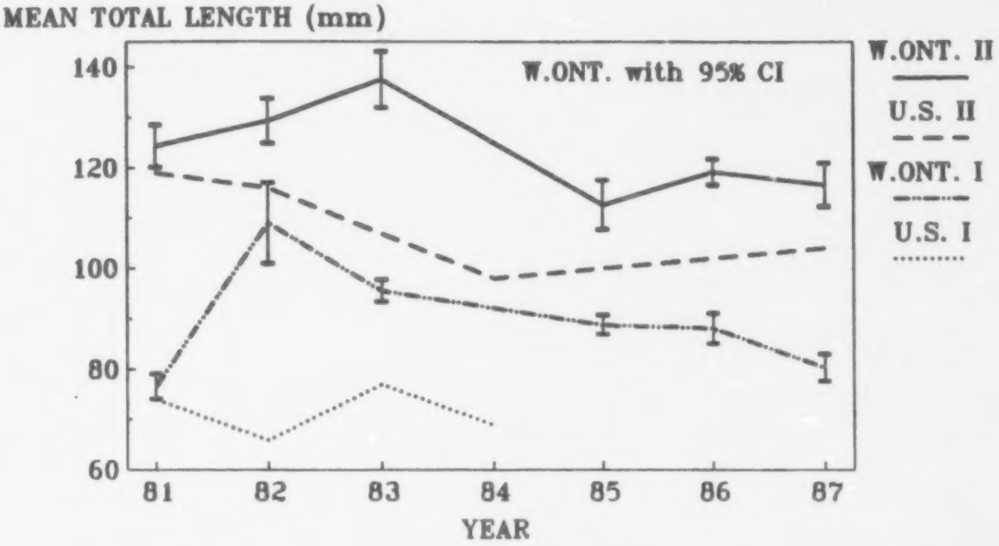

Figure 4. Mean size of smelt ages I-II in western and U.S. waters of Lake Ontario. U.S. data from O'Gorman et al. (1985 and 1988).

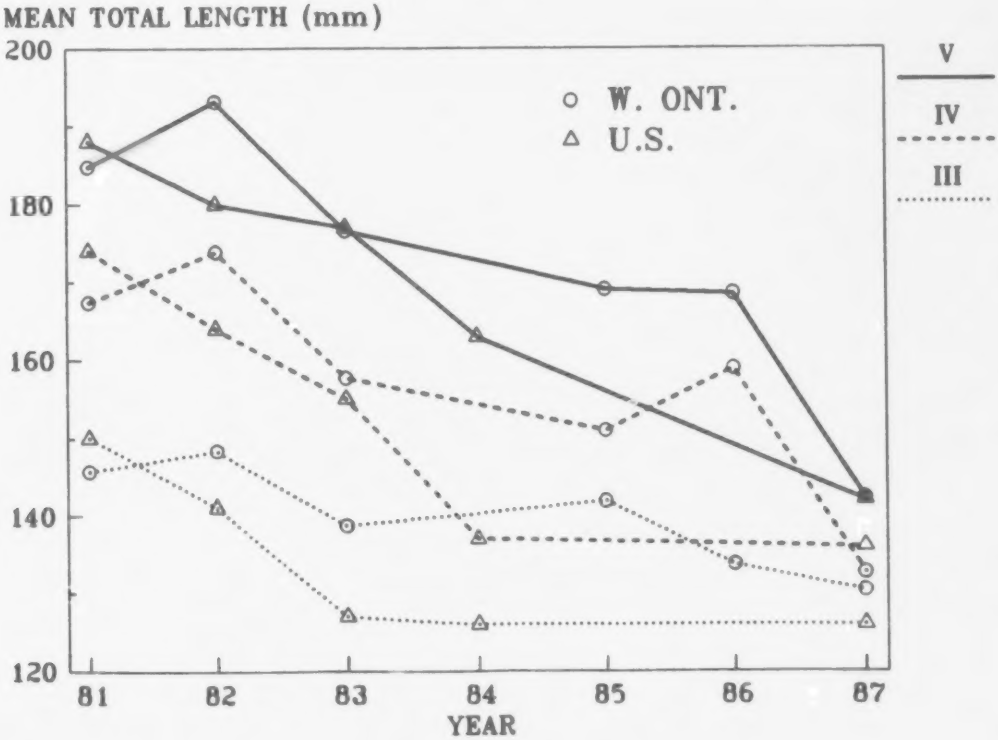

Figure 5. Mean size of smelt ages III-V in western and U.S. waters of Lake Ontario. U.S. data from O'Gorman et al. (1985 and 1988).

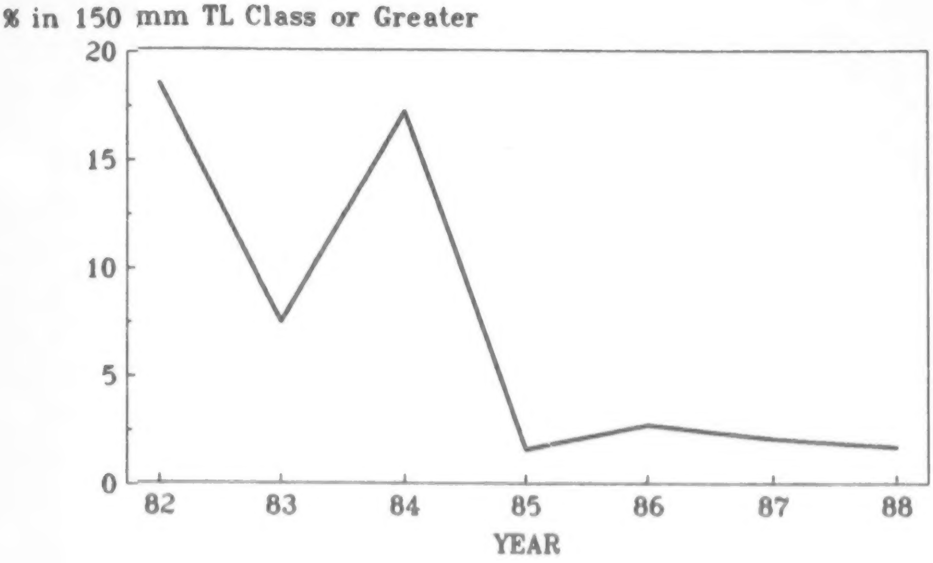

Figure 6. Percent of western Lake Ontario smelt in the 150 mm TL class or greater (i.e., ≥ 147.5 mm).

DISCUSSION

Abundance of smelt in western Lake Ontario over bottom areas of 10-50 m is similar to the abundance for the entire U.S. side of the lake (Fig. 2). The bottom area of western Lake Ontario is approximately 20-25% of the U.S. bottom area, implying that smelt density is about 5 times greater in western waters. The higher density could be due to increased diversity of thermal and structural habitat afforded by a more gradual drop-off typical of western Lake Ontario. One might expect that higher densities would be associated with reduced growth, but in contrast, growth of young smelt was higher in western Lake Ontario. The higher growth may be associated with increased available zooplankton biomass associated with greater nutrient flux or reduced competition from other planktivorous species. Alternatively, the density of alewife may be considerably lower in western Lake Ontario, reducing piscine interspecific competition.

O'Gormann et al. (1988) stated that in U.S. waters, the percent of smelt 150 mm and longer available to bottom trawls was 26% in 1981, 2% in 1985 and only 1% in 1987. They attributed this decline in large smelt to; (1) high mortality of smelt, presumably due to predation, when alewife decreased substantially in 1984, (2) a small 1983 year-class and (3) slow growth of young smelt in recent years. They considered the reduced growth of older smelt to be a consequence of depressed growth of young fish. We observed the same decline in abundance of larger smelt (Fig. 6) and concur that reduced growth of older smelt likely accounts for this change. However, we found that young smelt in western Ontario were larger than U.S. fish, yet older fish (ages III-V) were similar in size (Fig. 4 and 5). We can offer no alternative explanation for the reduced growth of larger smelt in recent years. Regional differences in the growth of young smelt imply that these age groups move less and that their growth is an expression of local conditions. Large smelt may be more mobile and the similarity of observed growth on the Canadian and U.S. sides may be a result of their broader seasonal distribution.

Salmonid predation may have contributed to the recent decrease in the number of large smelt. Salmonids prey on large smelt (Wismer 1983, Brandt 1986), and abundance of salmonids in western Lake Ontario, as indicated by angling catch per unit effort, has increased about four-fold from 1980 (Stewart 1989). Increased predation rates may coincide with a measurable shift in mortality rates of sizes and ages of smelt common to the diet. To test this hypothesis, size and age compositions of smelt in salmonid diets should be compared to age specific abundance and mortality determined from trawl catches.

The intent of this report was to provide a preliminary description of the abundance and growth of smelt in western Lake Ontario and to compare these data to published U.S. information. Much further insight would be gained by collaborating with American workers, to comprehensively describe smelt abundance, growth, and distribution in both American and western Lake Ontario. A lakewide persepective on the distribution and abundance of smelt and other forage fish populations should continue to be a goal. Currently, we have not developed methods to sample smelt and alewife in the central part of Lake Ontario (Toronto to Brighton), although midwater trawling has been considered (Schaner and Stewart 1989). The existing research data series of gillnets and bottom trawls for the Eastern Outlet Basin of Lake Ontario should also be analyzed and included in a comprehensive description of the forage stocks of Lake Ontario.

ACKNOWLEDGEMENTS

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REFERENCES

BRANDT, S. B. 1986. Food of trout and salmon in Lake Ontario. J. Great Lakes Res. 12:200-205.

CHRISTIE, W. J. 1972. Lake Ontario: effects of exploitation, introductions, and eutrophication on the salmonid communities. J. Fish. Res. Bd. Canada 29:913-929.

ELROD, J. H., C. P. SCHNEIDER, and W. DENTRY. 1986. Assessment of juvenile lake trout stocks in Lake Ontario, 1985. Report to the Lake Ontario Committee. GLFC, March 4-5, 1986.

HOENIG, J. M., and D. H. HEISEY. 1987. The use of a log-linear model with the EM algorithm to correct estimates of stock composition and convert length to age. Trans. Am. Fish. Soc. 116:232-243.

NYDEC/USFWS. Undated MS. Sampling protocol, rainbow smelt bottom trawl assessment, Lake Ontario. Cooperative fisheries study for NY State. 4 pp.

O'GORMAN, R., R. BERGSTEDT, and C. P. SCHNEIDER. 1983. Status of major forage stocks, U.S. waters of Lake Ontario, 1982. Report to the Lake Ontario Committee. GLFC, March 1-2, 1983.

O'GORMAN, R., R. BERGSTEDT, and C. P. SCHNEIDER. 1985. Status of major forage fish stocks in U.S. waters of Lake Ontario, 1984. Report to the Lake Ontario Committee. GLFC, March 5-6, 1985.

O'GORMAN, R., R. W. OWENS, C. P. SCHNEIDER, and T. H. ECKERT. 1988. Status of major forage fish stocks in U.S. waters of Lake Ontario, 1987. Report to the Lake Ontario Committee. GLFC, March 8-9, 1988.

REGIER, H. A., V. C. APPLEGATE, and R. A. RYDER. 1969. The ecology and management of the walleye in western Lake Erie. Great Lakes Fish. Comm. Tech. Rep. 15:101 pp.

SCHANER, T. and T. J. STEWART. 1989. Midwater trawling for smelt and alewife in the western basin of Lake Ontario. Report to the Lake Ontario Committee. GLFC, March 21-22, 1989.

STEWART, T. J. 1989. Western Lake Ontario harvest assessment, 1988. Report to the Lake Ontario Committee. GLFC, March 21-22, 1989.

WISMER, D. A. 1983. A preliminary report on the western Lake Ontario salmonid diet survey, 1983. Lake Ontario Fisheries Unit Rep. 84-4, OMNR, Richmond Hill, Ont.

Great Lakes Fishery Commission
Lake Ontario Committee
March 21-22, 1989
Buffalo, New York

SURVEILLANCE REPORT FOR LAKE TROUT REHABILITATION IN LAKE ONTARIO, 1988

by

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ABSTRACT

In 1988, lake trout in Lake Ontario continued to progress toward the goals laid out in the Joint Plan. Survival of young adults meet Plan objectives, but was poor for oldest lake trout: 67% at age 5 to 6, 44% at age 6 to 7, 49% at age 7 to 8 and 31% at age 8 to 9. Increasing mortality with age appears to be due to selection for larger fish by both sea lamprey and anglers. Although mortality for older fish is excessive, the trend has been declining. Other factors support the conclusion that more lake trout survived in 1988: (1) the average age of mature females increased 20% to 6.5 years, (2) carcass density (sea lamprey predation) declined 36% to near the lowest level ever observed, (3) the average age of carcasses increased to 6.1 years and (4) harvest by U.S. anglers was reduced 60% to 36,000 fish. In addition, the largest lake trout ever collected in our surveys (9 kg, 20 pounds) was taken near Oshawa and a new Lake Ontario angling record (10 kg, 22 pounds) was caught near Stony Island. Ninety five naturally produced lake trout fry were captured in fry traps at Stony Island, but similar trapping at Yorkshire Island and Charity Shoal was unsuccessful. Nearly 4,000 naturally deposited eggs were collected in the fall with small egg nets placed on different substrates on Stony Island reef, and one new net was more effective than the original design. Density dependent declines were observed in condition and maturity, but growth in length and recruitment were unchanged. Overall, the moderate improvement in many related factors indicate that reconstruction of a large, diverse lake trout spawning stock is well under way.

RECOMMENDATIONS

(1) To protect and maintain the recent gains noted in lake trout rehabilitation in Lake Ontario, managers should continue to restrain sea lamprey population growth and minimize lake trout exploitation by anglers.

(2) Creel survey efforts, whose geographic area is constrained by agency fiscal resources, should focus census effort on those areas where lake trout harvest is thought to be most intensive.

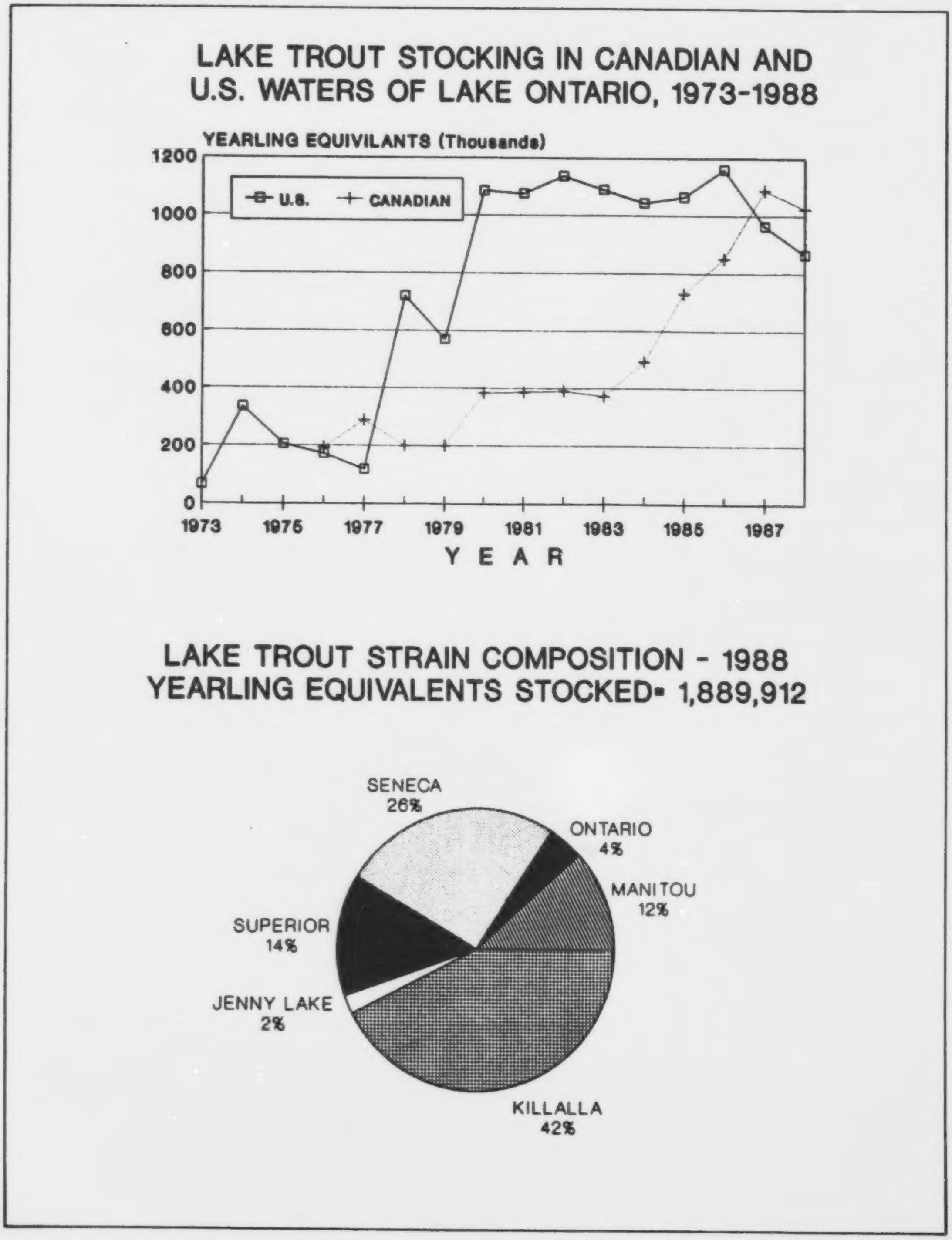
INTRODUCTION

Reconstruction of a naturally reproducing population of lake trout is the focus of a major international rehabilitation effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from many cooperating agencies developed a JOINT PLAN FOR THE REHABILITATION OF LAKE TROUT IN LAKE ONTARIO (Schneider, Kolenosky and Goldthwaite 1983), which identified a goal, an interim objective and several strategies for their achievement. The following report is organized along the same lines as the Joint Plan, with the intention to describe progress toward planned objectives. Assessment and monitoring methods have been described in detail in earlier reports; any readers interested in more information should review the appendices in the 1986 Surveillance Report (Schneider et.al. 1987).

STRATEGY 1: STOCKING

Since native stocks of lake trout in Lake Ontario are extinct, the major focus of our rehabilitation effort is the establishment of a new Lake Ontario strain(s). This entails rearing and introducing 2.5 million yearlings of various genetic stocks (1.25 million per nation), assessing strain performance, and emphasizing the use of progeny of lake trout that survived to maturity in Lake Ontario.

Numbers of lake trout stocked in 1988 declined from 1987: 866,340 and 1,023,572 yearling equivalents in U.S. and Canadian waters, respectively (Figure 1). Six genetic strains were stocked in 1988; in order of abundance they were: Killala, Seneca, Superior, Manitou, Ontario and Jenny Lakes strains (Figure 1). Generally, stocking within the last several years has been rapidly expanding in Canadian waters and slowly declining in U.S. waters. Consequently, the adult lake trout population in Canada should continue to increase for several years. The lower number of yearling equivalents planted in U.S. waters in the last two years resulted from loss of production space at the Allegheny National Fish Hatchery, due to allocation of more space for brood stocks.



LAKE TROUT STOCKING IN CANADIAN AND U.S. WATERS OF LAKE ONTARIO, 1973-1988

LAKE TROUT STRAIN COMPOSITION - 1988 YEARLING EQUIVALENTS STOCKED= 1,889,912

Figure 1.

STRATEGY 2: MAXIMIZING RECRUITMENT OF STOCKED FISH

The joint plan recommends maximizing recruitment of stocked lake trout by optimizing hatchery rearing practices and stocking techniques. The use of coded wire tags for marking fish has made it possible to initiate studies to evaluate the effects of rearing density, time of planting, and stocking method on post-stocking survival. All U.S. lake trout are reared at a single hatchery. Canadian fish are reared at four different hatcheries, two of which are pond stations. Since 1988, all fish stocked were uniquely marked. Studies of rearing density, stocking method and planting time in U.S. waters were described in detail last year (Schneider et.al 1988) and there was nothing new to report in 1988. In Canadian waters, it is too early to report results of similar types of special studies.

STRATEGY 3: MAINTAIN ADULT SURVIVAL BETWEEN 60-65%

Successful rehabilitation of lake trout in Lake Ontario not only requires stocking sufficient numbers and strains of fish, but also demands that enough planted fish survive to produce a viable spawning stock. The Joint Plan prescribes a survival rate of 60 to 65% per annum. To attain this level the plan further suggests that lake trout deaths from sea lamprey should be minimized and exploitation by the fishery should be limited.

Trends in Survival

Survival of adult lake trout from 1987-88 was estimated by comparing gill net relative abundance indices of individual year classes at successive ages (Ricker 1975, p.39). Survival for individual age groups continued to be good for young adults, but was poor for oldest lake trout: 67% at age 5 to 6, 44% at age 6 to 7, 49% at age 7 to 8 and 31% at age 8 to 9 (Figure 2, Appendix I). The weighted mean survival for lake trout, age 5 to 9, was 55%; down from 66% last year. These estimates indicated that mortality was greater in 1988 than 1987, but several other factors, discussed later in more detail, suggested that survival may have actually improved:

(1) Survival estimated from catch curves increased;
(2) Average age of mature females increased;
(3) Average age of lake trout carcasses increased;
(4) Principal sources of mortality declined;
    a) carcass density remained low in fall 1987[1];
    b) angler harvest decreased in 1988.

The improvement of survival of lake trout from age 5 to 6 was encouraging. During the early 1980's, survival estimates for this group were approximately 35%, and this may have been overestimated, because

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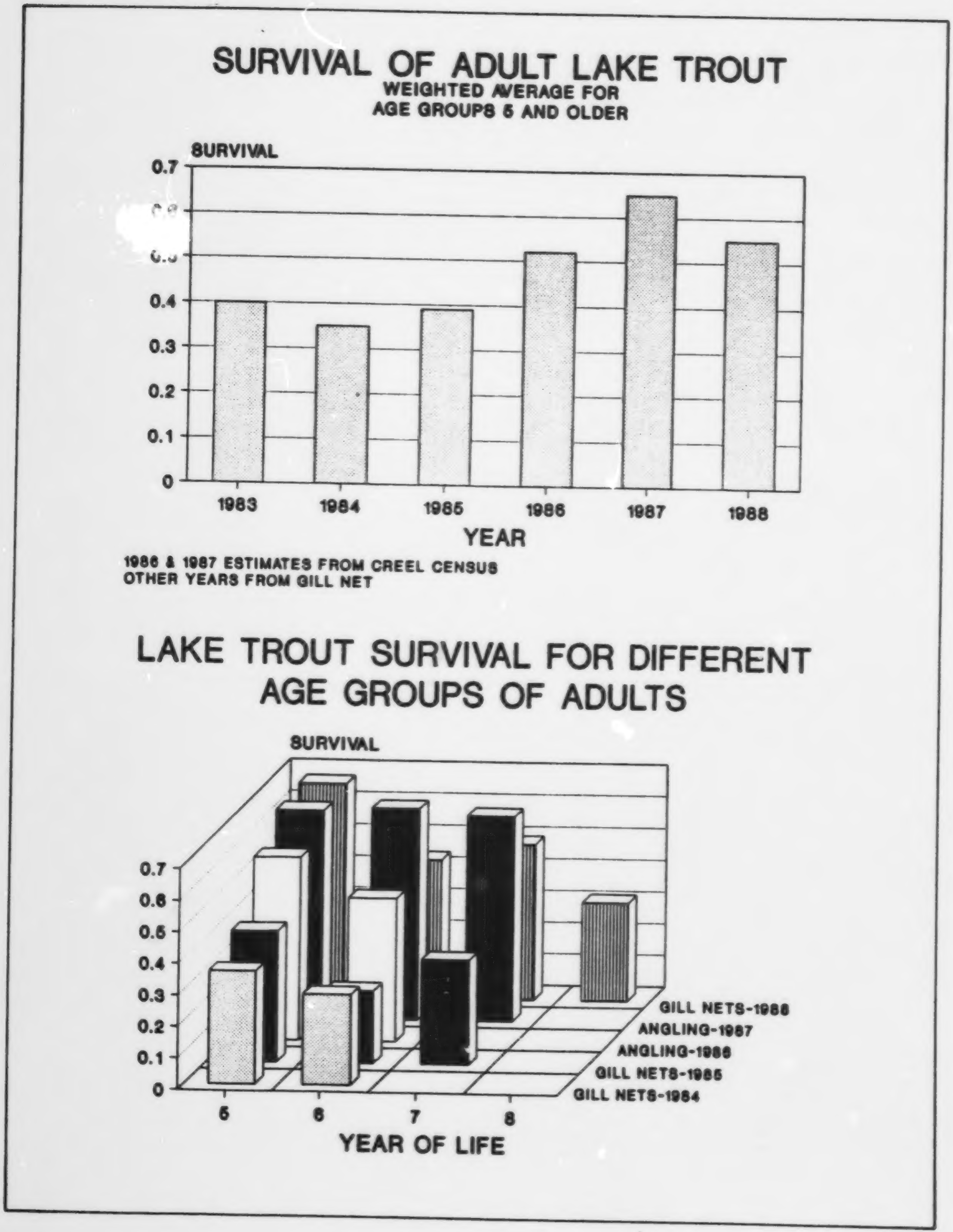
[1] The yearly period for these estimates is September 1 to August 31, with sea lamprey induced mortality occurring in the fall and angling mortality the following April to August.



SURVIVAL OF ADULT LAKE TROUT

WEIGHTED AVERAGE FOR AGE GROUPS 5 AND OLDER

1986 & 1987 ESTIMATES FROM CREEL CENSUS
OTHER YEARS FROM GILL NET

LAKE TROUT SURVIVAL FOR DIFFERENT AGE GROUPS OF ADULTS

Figure 2.

gill nets select for larger lake trout. In addition, few lake trout lived beyond age 6. In the mid-1980's, survival began to improve, reaching 66% and 67% for 1987 and 1988, respectively (Figure 2).

Both fishermen and sea lamprey actively seek the largest lake trout in the population; so it was not unexpected that lake trout mortality increased with age. Although survival of older adults was below standards recommended in the Joint Plan, the trend in survival has gradually improved; substantial numbers of age 9 fish were captured for the first time this year. The exceptional rates of survival (>64%) observed in 1987 at age 6 to 8, however, did not fit the pattern of more gradual improvement noted in other years. These estimates were based on creel census data, and it is possible that selection of large fish by anglers led to an overestimate of survival.

Comparing the abundance of individual year classes at successive ages has the advantage of providing information about survival in the current year. However, the technique has the potential for systematic bias, resulting from changes in catchability due to annual differences in distribution or behavior of fish. For example, in 1986 higher than expected gill net catches resulted in survival rates exceeding 100% for many groups of lake trout. Although survival calculated from creel census data during 1987 may have also been overestimated, survival was likely higher than that estimated from gill net catches in earlier years. Perhaps changes in lake trout distribution and/or behavior effect gill net and angling catches differently. The two collection techniques select lake trout from substantially different habitats; gill nets are deployed on the lake bottom, whereas, lake trout caught by fishermen are taken off-bottom at mid-depths.

Theoretically, survival estimates based on catch curves[2] are not biased by distortions due to catchability (Ricker 1975). However, estimates of survival from catch curves require that mortality be uniform with age, which it is not in Lake Ontario. For example, catch curves from 1984 to 1988 were all curvilinear (Figure 3) and survival decreased with age (Figure 2). Another limitation of catch curves is that they do not reflect current conditions. Rather, they provide an average estimate based on the total number of age classes considered. Also, if survival rates are changing, such as in Lake Ontario at the present time, estimates from catch curves lag behind the actual survival rate.

Accepting these constraints, catch curves still indicated that the trend in survival rate was improving steadily (Figure 3). Most importantly, catch curves did not show a decline in survival from 1987 to 1988; rather they showed an increase. The convex shape of these curves also confirmed the differential mortality among age groups observed by comparing year classes at successive ages. Although the trend has been toward improved survival of older adults, their rate of survival remains

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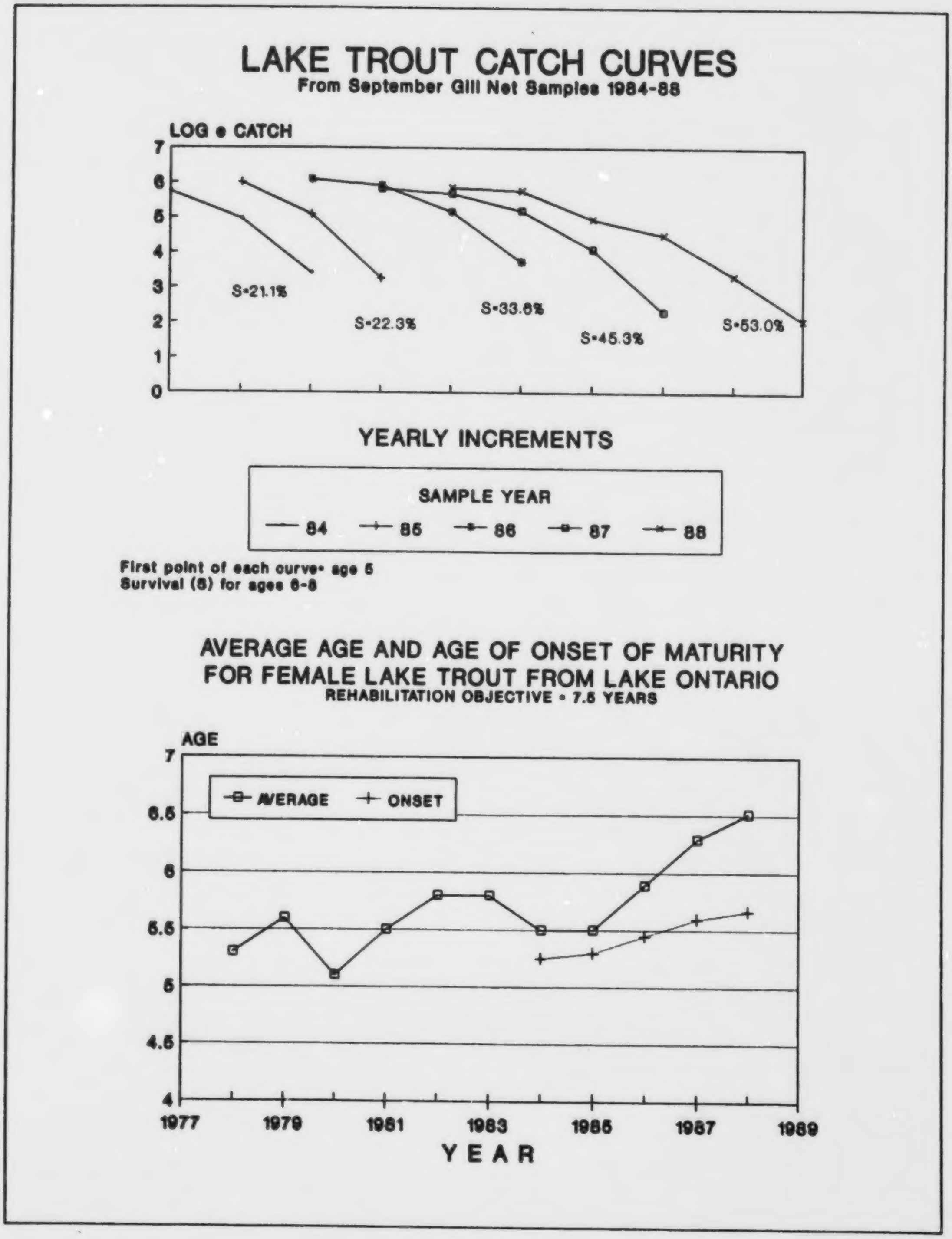
[2] Plotting the logarithm of the catch against age and using the slope of the line to estimate survival.



LAKE TROUT CATCH CURVES

From September Gill Net Samples 1984-88

YEARLY INCREMENTS

First point of each curve= age 5

Survival (S) for ages 6-8

AVERAGE AGE AND AGE OF ONSET OF MATURITY FOR FEMALE LAKE TROUT FROM LAKE ONTARIO

REHABILITATION OBJECTIVE = 7.5 YEARS

Figure 3.

below the guidelines recommended in the Plan. This continues to be an issue of great concern.

Average Age of Adult Females

One of the objectives of the rehabilitation program is to re-establish a suitably sized spawning stock that encompasses several year classes. The average age of mature females was selected as a measure of age composition. Older average ages indicate populations with more age groups and older fish. The current objective for average age is 7.5 years.

The average age of adult females taken in gill nets in U.S. waters increased for the third consecutive year to 6.5 years, the highest level ever observed and a 20% increase compared to 1987 (Figure 3). Part of the reason for the improvement is because females are taking longer to mature. For example, the age of onset of maturity for Superior strain females increased from 5.25 years in 1984 to 5.67 in 1988. However, the difference between average age and age at onset of maturity is the important factor, and it has been steadily increasing. Because stocking rates have been relatively stable in U.S. waters since 1980, most fish from earlier plantings have matured, therefore the recent increases in average age of mature females were undoubtedly related to improved survival.

Average age of mature females was not available from Canadian waters because accurate aging techniques were unavailable; the recent CWT marking policy will rectify this. Due to the recent expansion of stocking in Canadian waters, average age of adult females should initially decline, as larger numbers of newly mature females enter the spawning stock. Then, 5 to 6 years after stocking rates stabilize, average age of females should begin to improve gradually.

Minimize Losses From Sea Lamprey

Three basic approaches were outlined to minimize sea lamprey predation. First, and foremost, was to maintain adequate control of sea lamprey recruitment through the use of chemicals, barrier dams and/or other means. Increasing prey biomass should ultimately lead to reduced mortality of lake trout, since sea lampreys, under conditions of high density of large prey, are thought to function more like parasites than predators. The third tactic outlined in the plan was to stock genotypes of lake trout that were potentially resistant to sea lamprey induced mortality.

Monitor Sea Lamprey Impacts

Lake trout carcasses have been collected with bottom trawls in U.S. waters[3] each fall, since 1982. Results from these surveys provide direct and current evidence of sea lamprey induced mortality on lake trout. Total area swept by trawls during these fall surveys ranged from 40 ha. in 1982 to 485 ha. in 1985 and averaged approximately 390 ha. during 1985-88. Relatively few carcasses were recovered each fall; the least was 7 in 1983 and the most was 42 in 1985. In 1988, 19 carcasses were recovered from 390 ha. of lake bottom.

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[3] The lake bottom in U.S. waters is smoother and less obstructed than that on the Canadian side, and consequently, makes this type of effort-intensive sampling possible.

During the past year, a gear consultant[4], using electronic trawl mensuration equipment, provided more accurate estimates of the horizontal spread of trawls used for carcass surveys. The spread of one trawl was approximately 50% greater than previously thought, which meant that carcass densities reported in the past were overestimated. This problem was most acute in 1982-84. Carcass densities were recalculated using the new spreads.

Carcass density in the 30-99 m depth strata is the longest and most complete series (Figure 4). Density decreased 36%, from 0.094 in 1987 to 0.060 in 1988, but confidence intervals calculated using the Poisson distribution do not show a statistically significant change in carcass density between 1987 and 1988. Compared to 1982, carcass density was reduced significantly by 80%.

Marking rates have been used throughout the Great Lakes as a measure of lamprey activity. In Lake Ontario, there was a highly significant relation ($P<0.01$) between carcass density and average number of A1 marks per fish[5]. Carcass densities predicted from this relation all fell within the confidence intervals of the trawl estimates (Figure 4). Practically, this means: (1) average number of A1 marks in September could be used to forecast lamprey induced mortality, and (2) the historical record of A1 marking is probably a good reflection of actual lake trout mortality attributable to sea lamprey predation.

Past A1 marking rates suggest that there were three distinct periods of lamprey activity in Lake Ontario (Figure 4). From 1975 to 1980 marking, and presumably carcass density, was uniformly high (in excess of 0.06 A1 marks per fish) and from 1985 to 1988, rates were low and stable (less than 0.03). The transition between these two periods (1981 to 1984) was characterized by wide oscillations in marking and carcass densities. Since average A1 marks and carcass density are presumably related to sea lamprey abundance, it would not be unusual to see large oscillations at a time when a population was on a path to a new, lower equilibrium.

As carcass density declined from 1982 to 1988, the average age and size of carcasses increased (Figure 4). The increase in average age of carcasses (3.5 years in 1982 to 6.1 years in 1988) was highly sig

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[4] C. Christiansen, Sea Grant, Univ. Rhode Island

[5] Relations between density and Stage A1+A2 and Stage A1+A2+A3 were not statictically significant (Schneider et.al. 1988)

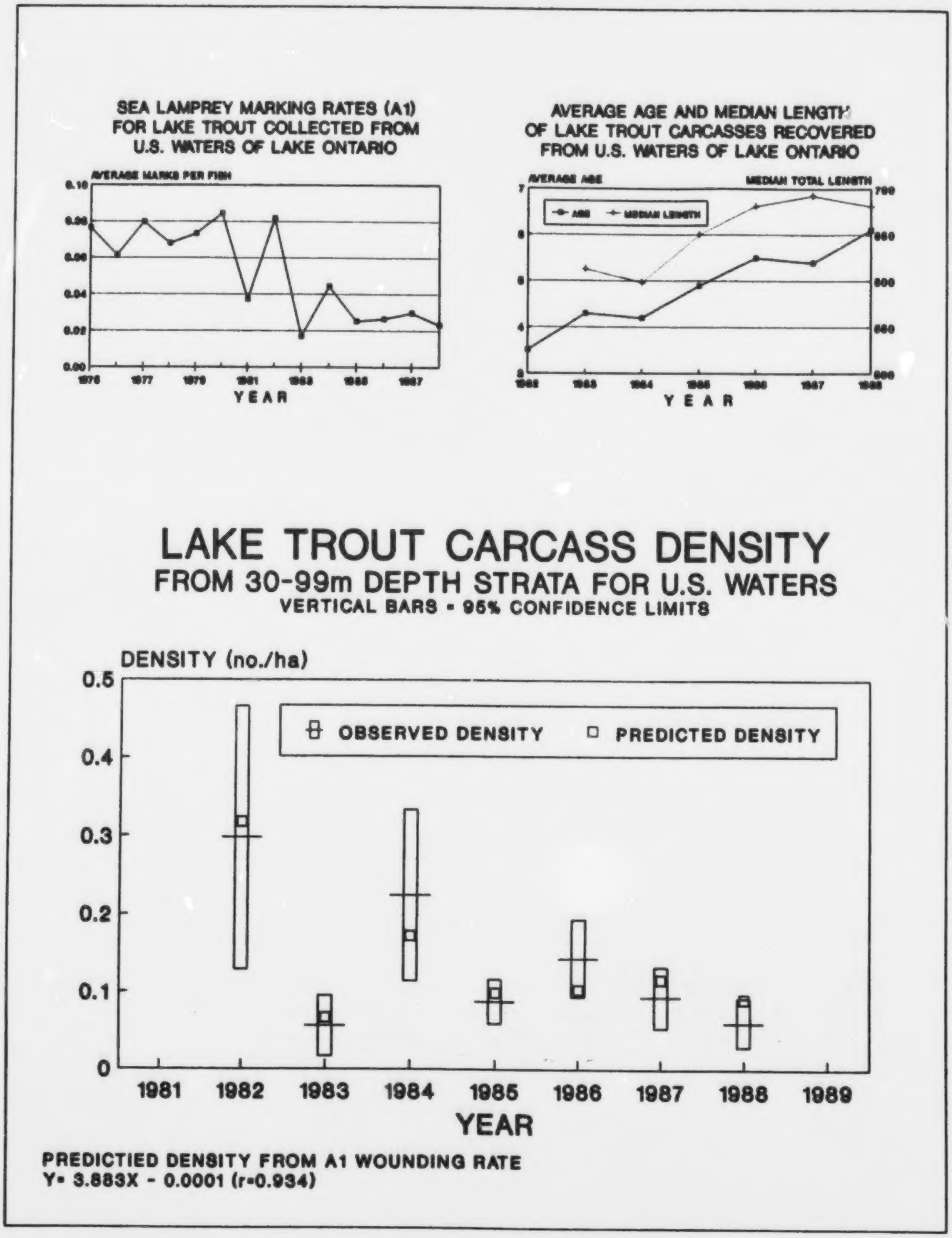
SEA LAMPREY MARKING RATES (A1) FOR LAKE TROUT COLLECTED FROM U.S. WATERS OF LAKE ONTARIO
AVERAGE MARKS PER FISH
0.10
0.08
0.06
0.04
0.02
0.00
1975
1977
1979
1981
1983
1985
1987
YEAR
AVERAGE AGE AND MEDIAN LENGTH OF LAKE TROUT CARCASSES RECOVERED FROM U.S. WATERS OF LAKE ONTARIO
AVERAGE AGE
MEDIAN TOTAL LENGTH
AGE
MEDIAN LENGTH
7
6
5
4
3
700
650
600
550
500
1982
1983
1984
1985
1986
1987
1988
YEAR
LAKE TROUT CARCASS DENSITY
FROM 30-99m DEPTH STRATA FOR U.S. WATERS
VERTICAL BARS = 95% CONFIDENCE LIMITS
DENSITY (no./ha)
OBSERVED DENSITY
PREDICTED DENSITY
0.5
0.4
0.3
0.2
0.1
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
YEAR
PREDICTIED DENSITY FROM A1 WOUNDING RATE
Y= 3.883X - 0.0001 (r=0.934)

Figure 4.

nificant ($P<0.001$). The trend in median total length was also significant ($P<0.02$). The relation between average age of carcasses and mean total length of A1 marked lake trout was highly significant ($P<0.01$).

Increase Prey Biomass

The number of the mature lake trout in Lake Ontario has grown substantially over the last eight years (Figure 5). Since 1980, relative abundance of mature males and females in U.S. waters increased significantly ($P<0.001$, $P<0.01$, respectively), but in recent years rate of expansion has slowed[6]. There was no statistically significant trend for immature lake trout ($P>0.05$). In Canadian water, immature fish and mature males have increased significantly ($P<0.05$), since 1984.

An abundant population of larger, older lake trout should attract sea lamprey attacks, and these lake trout should better survive those attacks. In theory, sea lamprey should become true parasites, rather than predators. Although, the lake trout populations in both Canadian and U.S. waters of Lake Ontario are continuing to expand and the average sizes have increased, sea lamprey continue to be predators rather than parasites.

Limit Exploitation

Fishing is the other major, controllable component of lake trout mortality in Lake Ontario. Creel surveys provide an effective and reliable means for quantifying the number of lake trout killed by anglers. This information, in conjunction with carcass survey estimates should permit a reasonable assessment of the corrective actions necessary to improve survival.

Canadian and U.S. creel surveys conducted in 1988 did not sample all fisheries. There were no Canadian surveys conducted in the Eastern and Central Basins of Lake Ontario in 1988. This was unfortunate, because lake trout harvest was greatest in the Eastern Basin in 1987 and likely expanded in 1988, whereas in the Western Basin, lake trout harvest was minimal (Table 1). Although the U.S. creel surveys did not census the Eastern Basin either, the comprehensive survey conducted in 1984 suggested that U.S. harvest estimates for 1985 to 1988 probably represented about 85% of the actual harvest.

Harvest of lake trout by sport fishermen remained low in the Western Basin of Canadian waters and declined dramatically on the U.S. side (Table 1). During 1984-87, lake trout harvest in U.S. waters was stable, at approximately 85,000 fish. On October 1, 1987 DEC implemented restrictions on lake trout harvest, in order to further reduce fishing mortality and enhance rehabilitation efforts. The season was

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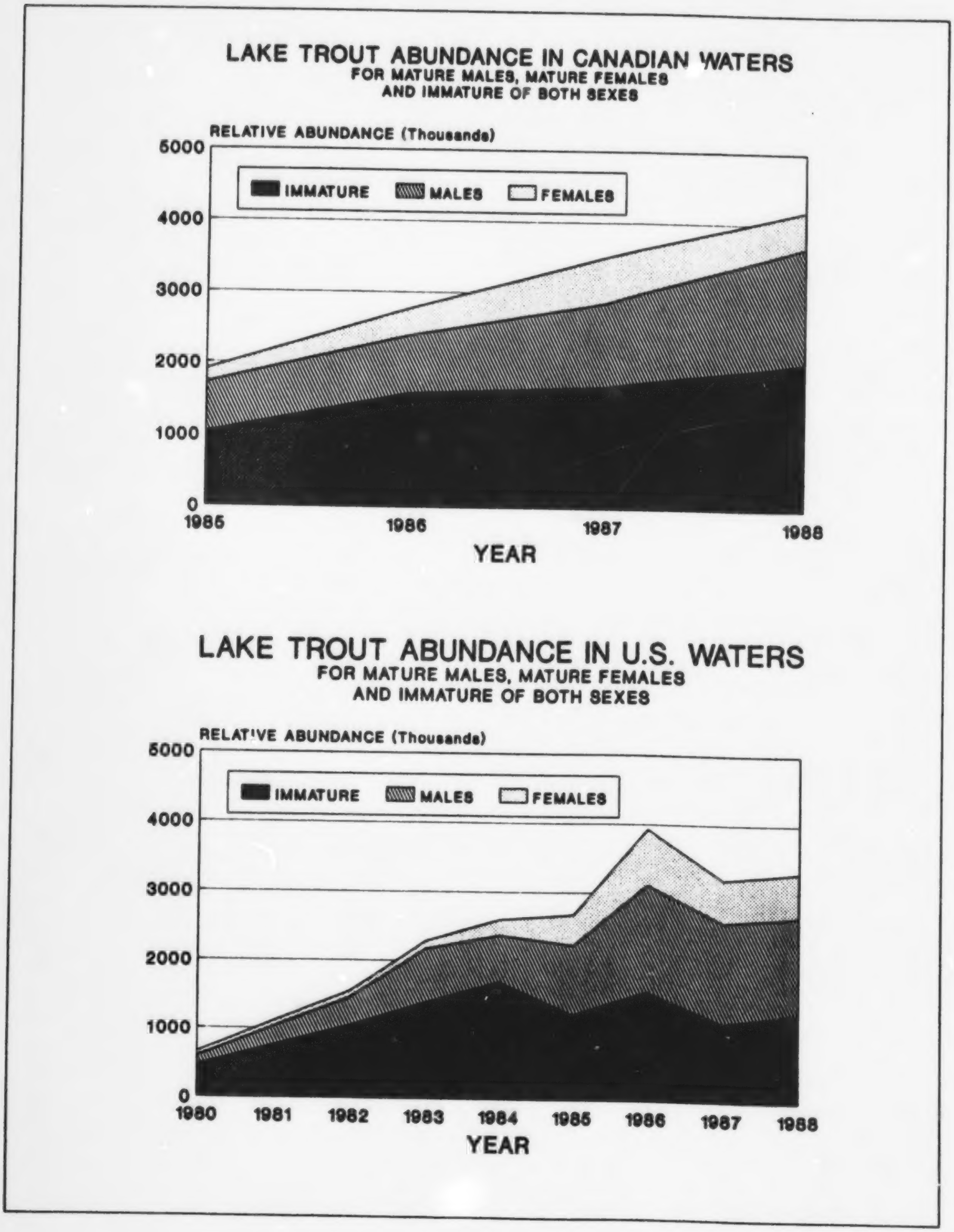
[6] The high relative abundance observed in Figure 5 for 1986 was an aberration, because of a shift in catchability.



LAKE TROUT ABUNDANCE IN CANADIAN WATERS
FOR MATURE MALES, MATURE FEMALES
AND IMMATURE OF BOTH SEXES

LAKE TROUT ABUNDANCE IN U.S. WATERS
FOR MATURE MALES, MATURE FEMALES
AND IMMATURE OF BOTH SEXES

Figure 5.

closed from October 1 to December 31, and most importantly, a slot size limit required the release of all lake trout between 635 mm (25 inches) and 762 mm (30 inches). In 1988, the effect of these restrictions reduced harvest by nearly 60% to 36,000.

Table 1. A summary of lake trout harvest and angling effort.

	YEAR				% Change
	1985	1986	1987	1988	1987-88
Completed Boat Trips:					
Canada Western Basin	35,700	48,039	55,447	59,650	
Central Basin	-	-	16,078	unkn	
Eastern Basin	-	-	7,986	unkn	
Totals	35,700	48,039	79,511	unkn	
United States	163,548	175,743	195,358	187,121	-4.3%
Lake Trout Harvest (#'s):					
Canada Western Basin	2,227	1,710	2,567	1,421	
Central Basin	-	-	261	unkn	
Eastern Basin	-	-	7,910	unkn	
Totals	2,227	1,710	10,738	unkn	
United States	83,145	85,064	88,742	36,037	-59.4%

The improvement observed in adult lake trout survival in U.S. waters was not only the result of reduced mortality from sea lamprey predation, but also from a substantial decline in angler and commercial harvests. Relative exploitation (harvest/relative abundance) by anglers declined by 54% from 1987 (Figure 6). The declining trend in exploitation from 1984 to 1988 was highly significant ($P<0.01$). There was also a progressive shift of the impact of angling to the older, mature fish (Letendre et.al. 1989). Obviously, reduced exploitation by U.S. anglers contributed to improved survival, but not all age groups of lake trout benefited equally.

In 1988, OMNR continued its 'willing seller willing buyer' buy-out program, and new time and area specific fishing season restrictions were also announced. As a result, Canadian incidental catches of lake trout have declined. U.S. commercial fisheries are less extensive and are localized near the Eastern Basin. A partial estimate of Canadian incidental catches of lake trout in the small mesh gill net fishery for yellow perch is estimated to be at least 1,246 kg., and total catches in all other fisheries could account for up to 5,000 kg. For U.S. waters, magnitudes of the incidental catch is unknown, but it could be appreciable, especially to local spawning stocks.

Overall, the known forms of harvest in both U.S. and Canadian waters are a substantial component of lake trout mortality. Losses of lake trout through illegal commercial and recreational fishing are unknown, but could also be sizable.

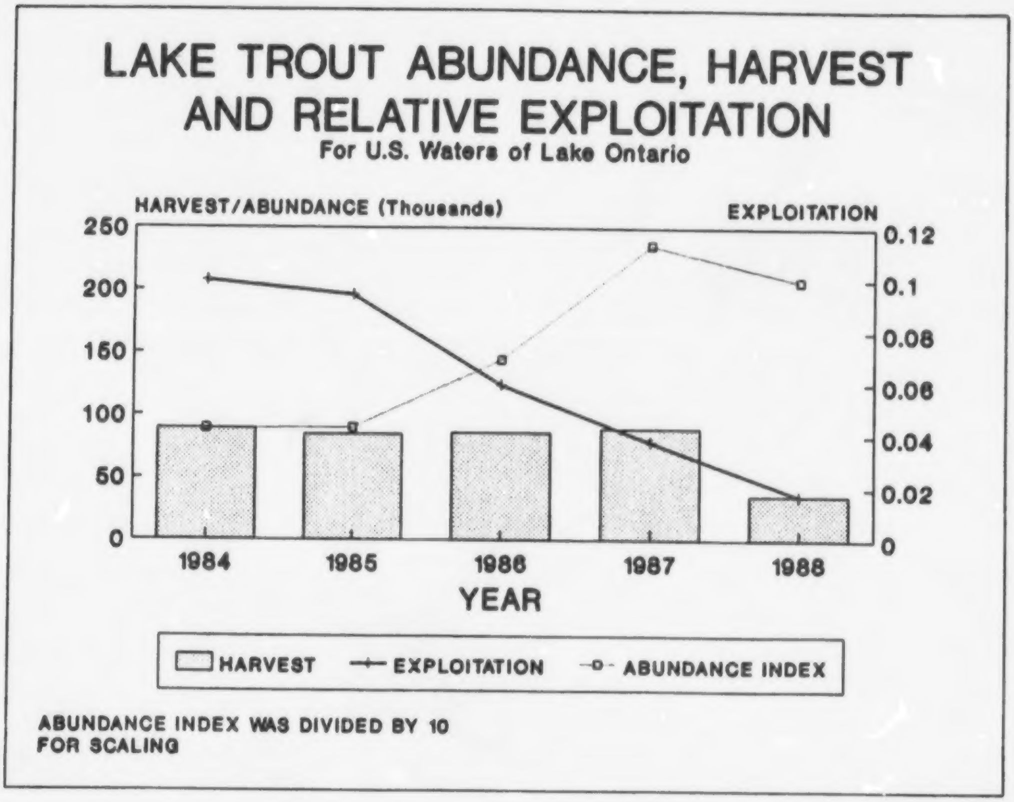


Figure 6.

STRATEGY 4: MAXIMIZE REPRODUCTIVE POTENTIAL

In the Joint Plan degradation of the ecosystem was not considered a causal agent in the demise of native lake trout, principally because lake trout were declining prior to the period of most intensive eutrophication and contamination. However, habitat quality is now diminished and may hinder rehabilitation. The suggested approach to maximizing reproductive potential of the new Lake Ontario stock involves: (1) improving water and habitat quality, (2) maximizing use of the least degraded spawning and nursery habitat and (3) determining those conditions on the spawning grounds which may be inhibiting successful reproduction.

Spring Fry Collections

Spring fry trapping was conducted at three sites within the Eastern Outlet Basin of Lake Ontario during 1988: Stony Island, Yorkshire Island and Charity Shoal. Approximately 80 and 125 traps were fished at

Yorkshire Island and Charity Shoal, with no fry collected at either site. Eighty-eight fry traps were deployed on Stony Island reef from April 5 to June 7, 1988. The traps were placed on the eastern edge of the reef, in the same location where fry were captured in 1986 and 1987. The traps were checked every 5 to 11 days. A total of 95 fry were captured, including a single fry found in the stomach of a sculpin caught in a trap (Table 2). The catch per unit effort was 0.02 fry/trap day, compared to 0.04 and 0.002 fry/trap day in 1986 and 1987. All fry were taken to Cornell University for genetic analysis to identify their strain parentage.

Table 2. Lake trout fry catch rates

DATE	NO. TRAPS	NO. FRY	FRY PER TRAP-DAY	% EMERGENT FRY
APR 6	88	-	-	-
APR 12	88	12	0.023	25%
APR 22	83	24	0.029	0%
MAY 3	84	29	0.030	14%
MAY 8	87	22	0.051	23%
MAY 16	83	6	0.008	33%
MAY 22	86	1	0.002	100%
JUN 2	85	0	0	
JUN 7	85	0	0	
TOTALS:		95[a]		

[a] Date of capture of one fry was not recorded.

A 5 m (16') otter trawl, with a 12.5 mm (0.5") stretch-mesh cod end liner, was deployed on May 23, but captured no lake trout fry. Two dead eggs, which appeared to be lake trout eggs, were recovered in the trawl.

Alewife Gillnetting

Three gangs of monofilament,sinking gill nets were placed on Stony Island reef on May 17 and May 23 to capture potential predators of lake trout fry. Each gang consisted of 61 m (200') of 38 mm (1.5") stretch mesh, 61 m of 25 mm (1") stretch mesh and 30 m (100') of 19 mm (0.75") stretch mesh. All three gangs were set in an SW-NE direction on and adjacent to the spawning reef in 3.7 to 11.0 m (12-26') depth. The gangs were set just before sunset, and lifted 1.5-2 hours later. One hundred and fifty-three fish were captured; the majority were alewife. All fish captured were preserved immediately in formalin; no fish of any species were found in the stomachs.

Fall Egg Trapping

Four lines of 25 egg nets were deployed on Stony Island reef on October 15, 1988. One line was placed on each of four substrate types: sand, gravel, small cobble, and large rubble. An additional line of 34 experimental egg traps was deployed to compare the capture efficiency of three new egg trap designs with the original egg net. One of the new trap designs appeared to capture eggs more efficiently and damage eggs less than the original egg net design. The nets were lifted and replaced every 3-15 days through December 8. Egg deposition appears to have been concentrated on large rubble substrate at the eastern edge of the reef. A total of 3,995 eggs were collected (Table 3); the peak of egg deposition was in mid-November. Four eggs collected on December 8 were eyed. 1,118 live eggs were placed in a hatchery at Cornell; 673 (60%) survived to eye-up by January 14, 1989.

Table 3. Egg collection rates.

DATE	NO. EGGS	EGGS PER NET-DAY
OCT 20	41	0.04
OCT 31	57	0.05
NOV 15	1,918	1.09
NOV 22	1,638	2.46
NOV 25	44	0.15
DEC 8	297	0.23
TOTAL:	3,995	x=0.81

Genetic Analysis of Lake Trout Fry

All fry captured on Stony Island reef from 1986 to 1988 were examined for genetic variation at 18 loci using horizontal, starch-gel electrophoresis. Each of the strains stocked into Lake Ontario prior to 1982, which could have produced fry by 1986 (Clearwater, Manitou, Superior and Seneca), were examined at the same loci. Two strains stocked in low numbers prior to 1977 were not sampled (Mishibishu and Green Lake). Genetic data from the stocked strains were used in combination with a modified mixed stock analysis program to determine the parental origins of the fry. This analysis was also used to identify the strain composition of five year classes of the Lake Ontario strain, and a sample of eggs collected during spawning on Stony Island reef in 1987. Greater than 73% of the fish, in all but two samples, were produced entirely by the Seneca and Superior strains. In the 1987 Lake Ontario strain year class, and the 1988 Lake Ontario strain year class collected from Charity Shoal, 20-30% of the fish were Seneca x Manitou crosses.

Trawl Catches of Juveniles

Catches of juvenile lake trout, during bottom trawls surveys in July-August, indicate that few, if any, naturally produced lake trout survived to age 1. During 1984-88, 3,574 lake trout <250 mm long were captured. Only 105 of these were unclipped and a coded wire tag was recovered from 102. The three unclipped fish, from which a coded wire tag was not recovered, may have been hatchery-reared fish that did not receive a discernible adipose fin clip, and which also shed the coded wire tag shortly after they were tagged.

DENSITY DEPENDENT EFFECTS

The Joint Plan recognized that density dependent population responses could confound the attainment of plan objectives. The plan forecast that as the lake trout population expanded, growth rates would decline, age at maturity would increase, fecundity would be reduced, and natural mortality could increase. These kinds of changes were not intended to forebode a population collapse; instead, they are normal responses that should be expected as the population increases.

Condition

Lake trout condition declined significantly, since 1978, but improved slightly within the last two years. Weight-length regressions calculated from fish taken in September gill net surveys were used to predict the weight of a 600 mm fish (Figure 7). Predicted weight declined significant ($P<0.001$) over the 10-year period; however, the average weight reduction was very small, only 38 g per year.

At the same time condition declined, adult abundance increased (Figure 5). The inverse relation between predicted weight and adult relative abundance was highly significant ($P<0.001$, $r= 0.937$), but the severity of the decline in condition was minimal, less than one-half kilogram (a pound) in ten years.

Maturity

Female lake trout took longer to mature and this decline was inversely related to adult abundance. In 1984, 74% of age 5 Superior strain females were mature; while in 1988, only 51% were mature (Figure 7). Since 1982, maturity declined significantly ($P<0.02$, 5.7% per year) and the average age of maturity (onset of maturity, Figure 3) showed a significant increase from 1984-88 ($P<0.01$). Both these measures of maturity were related to adult relative abundance ($P<0.05$, $P<0.02$).

Length In spite of reduced condition and maturity, growth in length of lake trout was unchanged in recent years. Total lengths of Superior strain lake trout, ages 2 to 7, did not change appreciably from 1979 to 1988 (Figure 7). There were no statistically significant differences in slopes of regressions of length on year ($P>0.05$).

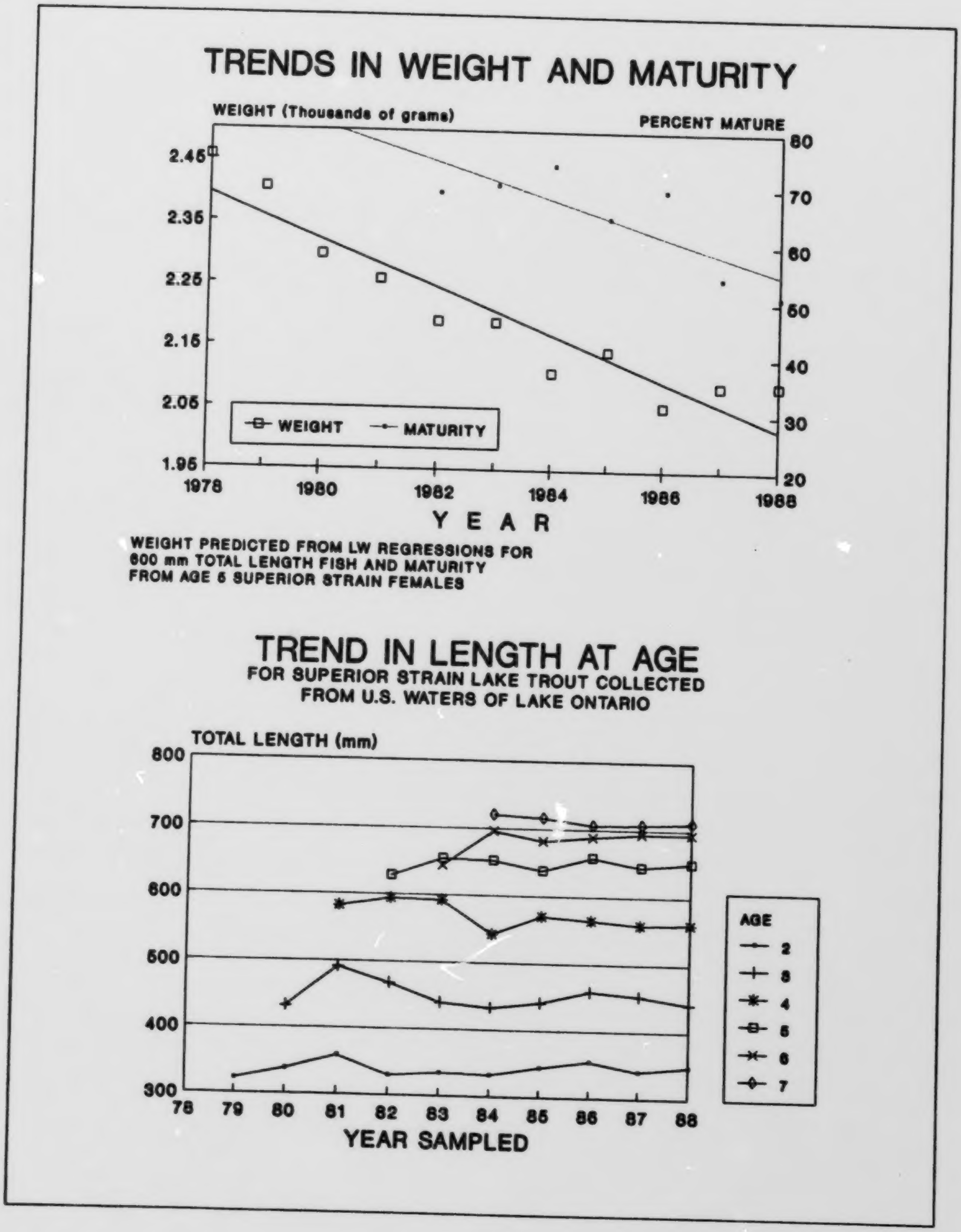

TRENDS IN WEIGHT AND MATURITY
WEIGHT (Thousands of grams)
PERCENT MATURE
2.45
2.35
2.25
2.15
2.05
1.95
80
70
60
50
40
30
20
1978
1980
1982
1984
1986
1988
YEAR
WEIGHT
MATURITY
WEIGHT PREDICTED FROM LW REGRESSIONS FOR 600 mm TOTAL LENGTH FISH AND MATURITY FROM AGE 6 SUPERIOR STRAIN FEMALES
TREND IN LENGTH AT AGE
FOR SUPERIOR STRAIN LAKE TROUT COLLECTED FROM U.S. WATERS OF LAKE ONTARIO
TOTAL LENGTH (mm)
800
700
600
500
400
300
78
79
80
81
82
83
84
85
86
87
88
YEAR SAMPLED
AGE
2
3
4
5
6
7

Figure 7

Recruitment

Although condition and maturity declined, numbers of immature lake trout were not limited by adult abundance. Relative abundance of immature lake trout taken with gill nets from U.S. waters (Figure 5) increased an average of 29% per year from 1980 to 1984 (P<0.001), in response to the major increase in stocking that began in 1980 (Figure 1). Since 1985, relative abundance of immature fish declined, but that reduction was small and not significant (2% per year, P>0.05). Last year, it appeared that survival of age 2 lake trout, captured in trawls at Hamlin, was declining, but survival improved in 1988.

REFERENCES

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Department of the Environment, Fisheries and Marine Service, Bull. 191.

SCHNEIDER, C.P., T.H. ECKERT, J.H. ELROD, R. O'GORMAN, W. DENTRY, M.E. DANIELS, J.E. MARSDEN, C.C. KRUEGER and P.G. SLY. 1987. Lake trout rehabilitation in Lake Ontario, 1986. Great Lakes Fishery Commission, Lake Ontario Committee Meeting, Buffalo, New York.

SCHNEIDER, C.P., T.H. ECKERT, J.H. ELROD, R. O'GORMAN, R.W. OWENS, W. DENTRY, J.E. MARSDEN AND C.C. KRUEGER. 1988. Lake trout rehabilitation in Lake Ontario, 1987. Great Lakes Fishery Commission, Lake Ontario Committee Meeting, Gananoque, Ontario.

SCHNEIDER, C.P., D.P. KOLENOSKY and D.B. GOLDTHWAITE. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario. Great Lakes Fishery Commission, Lake Ontario Committee, Spec. Publ. 50 p.

APPENDIX 1

Relative abundance and survival estimates for lake trout collected during September gill net assessments from Canadian and U.S. waters from 1987 and 1988.
[Survival = 1988 abundance index/ 1987 abundance index]

YEAR CLASS	STRAIN	SITE STOCKED	1987 NUMBER	1987 ABUNDANCE	1988 NUMBER	1988 ABUNDANCE	ANNUAL SURVIVAL	WEIGHTED SURVIVAL	
								STRAIN	AGE CLASS
1979	SUP	ALL	37	77,605	13	21,074	27.2%	SUP 8 9	AGES 8 9
		NIA1	4	3,376	1	815	24.1%	31.1%	31.1%
		HAM1	12	21,490	5	12,362	57.5%		
		SBL1	4	11,245	1	1,100	9.8%		
1980	CWL	HAM1	4	6,627	2	2,006	30.3%	CWL 7 8	AGES 7 8
		SOD1	6	8,215	1	2,170	26.4%	36.4%	49.1%
		SBL1	3	13,131	2	4,940	37.6%		
		DAB1	3	8,744	1	4,234	48.4%		
	SBN	STO1	6	5,289	16	6,790	128.4%	SBN 7 8	
		DAB1	3	10,939	3	2,857	26.1%	59.4%	
	SUP	ALL	60	126,725	21	58,392	46.1%		
		NIA1	6	6,180	1	4,014	65.0%	SUP 7 8	
		NIA2	9	9,172	2	5,588	60.9%	50.2%	
		HAM1	11	10,601	4	6,042	57.0%		
		HAM2	10	12,315	12	15,118	122.8%		
		SOD1	11	18,522	6	6,113	33.0%		
		SOD2	10	21,495	3	5,141	23.9%		
		SBL1	15	27,661	7	22,803	82.4%		
		SBL2	11	26,388	3	10,864	41.2%		
		STO1	4	17,620	1	4,781	27.1%		
1981	CWL	ALL	61	94,400	32	69,049	73.1%	CWL 6 7	AGES 6 7
		NIA1	11	8,858	6	18,447	208.3%	50.6%	43.7%
		HAM1	10	14,783	1	1,650	11.2%		
		SOD1	8	16,314	6	6,963	42.7%		
		SBL1	9	20,393	4	9,335	45.8%		
		STO1	20	49,201	5	6,153	12.5%		
		DAB1	10	28,876	3	6,251	21.6%	SBN 6 7	
	SBN	DAB1	6	19,237	6	14,874	77.3%	77.3%	
	SUP	NIA1	7	7,893	4	6,655	84.3%		
		NIA2	9	14,041	4	7,994	56.9%	SUP 6 7	
		HAM1	32	61,982	11	15,378	24.8%	37.8%	
		HAM2	13	43,488	11	17,855	41.1%		
		SOD1	21	41,321	11	16,029	38.8%		
		SOD2	13	17,454	5	13,838	79.3%		
		SBL1	12	22,644	9	23,054	101.8%		
		SBL2	15	38,118	6	9,967	26.1%		
		STO1	14	25,428	8	15,881	62.5%		
		STO2	14	52,044	10	10,337	19.9%		
		DAB1	16	54,570	2	6,304	11.6%		

Appendix 1 concluded

YEAR CLASS	STRAIN	SITE STOCKED	1987 NUMBER	1987 ABUNDANCE	1988 NUMBER	1988 ABUNDANCE	ANNUAL SURVIVAL	WEIGHTED SURVIVAL STRAIN	WEIGHTED SURVIVAL AGE CLASS
1982	CAN	DUK	48	156,164	23	92,298	59.1%	CAN 5 6	AGES 5 6
	CWL	NIA1	11	18,260	12	31,383	171.9%	59.1%	67.2%
		HAM1	16	12,877	23	27,732	215.4%		
		SOD1	9	13,951	6	16,135	115.7%	CWL 5 6	
		SBL1	4	10,042	1	3,048	30.4%	64.1%	
		STO1	29	74,995	7	7,278	9.7%		
		DAB1	11	25,774	4	14,403	55.9%		
	SEN	STO1	6	15,205	7	15,630	102.8%	SEN 5 6	
		DAB1	6	24.288	6	9,915	40.8%	64.7%	
	SUP	ALL	64	152,071	70	136,782	89.9%		
		NIA1	9	9.012	7	14,054	155.9%	SUP 5 6	
		NIA2	6	11.235	10	20,382	181.4%	70.2%	
		HAM1	24	65.215	28	51,836	79.5%		
		HAM2	29	61,175	37	67,873	110.9%		
		SOD1	15	32,887	13	26,851	81.6%		
		SOD3	20	39,939	10	10,343	25.9%		
		SBL1	17	50.672	15	33,018	65.2%		
		SBL3	18	52,466	15	28,448	54.2%		
		STO3	21	68,332	7	11,253	16.5%		
		DAB3	27	72,372	11	31,161	43.1%		
		TOTALS:	920	2,041,317	561	1,123,041	WEIGHTED MEAN SURVIVAL=		55.0%
							UNWEIGHTED MEAN SURVIVAL=		44.3%

Great Lakes Fishery Commission
Lake Ontario Committee Meeting
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LAKE ONTARIO SEA LAMPREY ASSESSMENT

by

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ABSTRACT

Lake Ontario sea lamprey indices in 1988 continued the trend toward lower abundance that began about 1986. That change was attributed to lampricide treatments initiated in the Oneida Lake system in 1984 and was augmented by continuation of salmonid expansion resulting from stocking programs. Those factors together with a decreased sport harvest effect allowed substantial increase in survival of lake trout.

A brief interruption of this favorable balance could result from cancellation of a very large 1988 Oneida Lake lampricide treatment. That should not have serious consequences but effects will be closely watched.

A more ominous threat exists in proposed funding reductions for the lampricide program which would precipitate very serious sea lamprey resurgence in Lake Ontario. However, efforts are underway to have full funding provided to the Great Lakes Fishery Commission (GLFC) so it is premature to make proposals for responsive action at this time.

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RECOMMENDATIONS

1. Every needed effort should be made to assure lampricide treatment of the Fish Creek system during 1989 to prevent escapement of substantial numbers of transformed sea lampreys for a second consecutive year.

2. Other lampricide treatments and ongoing sea lamprey/salmonid sampling should be exercised proficiently as in the past in order to maintain the existing excellent levels of sea lamprey control and population assessment.

3. Untreated sea lamprey infestations in Niagara River and Seneca River tributaries should be appraised and recommendations made for appropriate control measures, if any.

4. Surveillance should be maintained in previously uninfested waters to detect new sea lamprey colonizations that may occur as a result of continuing improvement in water quality.

INTRODUCTION

This represents a continuing joint effort by the agencies working on Lake Ontario to bring all adult sea lamprey monitoring results together in a single report. Emphasis is on trend-through-time series of biologically stratified and standardized sampling programs.

The lampricide treatment of a very large sea lamprey infestation in the Oneida Lake system in 1984 was the most noteworthy new sea lamprey control action in the Lake Ontario watershed in recent years. Evaluation detected reduction of sea lamprey indices in 1986 and 1987 and a corresponding increase in lake trout survival that was also helped by a gradually declining sport fishing mortality (Schneider, et al 1988). Effort continues to be focused on evaluating the Oneida Lake action and other sea lamprey control actions.

METHODS

Previous reports have fully described the methods employed for obtaining the data reported herein, and headings of the data tabulations generally describe how the data were obtained. Only brief descriptions are provided below.

I. Wounding

The terms "wound" and "wounding" as used in this report may refer to any type or stage of lamprey-inflicted lesion when used in a non-specific sense. Where specificity is intended, terminology used is in accordance with King and Edsall (1979). Wounding statistics are taken from all available salmonid species samples which provide stratification of age or size, life history, method and time of capture. Age designations in Roman numerals utilize the convention of assigning a year of age to each winter mark on the fish's scales, which also corresponds to year class.

Incidence of wounding on salmonids is influenced by salmonid abundance, sea lamprey abundance and salmonid mortality. The conceptual relationship may be expressed as:

$$\text{Observed Wounding} = \frac{(\text{Lampreys} \times \text{Attack Frequency} \times \text{Time})}{\text{Salmonids}}$$

minus wounding on salmonids killed

II. Parasitic-Phase Sea Lampreys

Parasitic phase sea lampreys have been collected via voluntary contributions from sport fishermen participating in the Empire State Lake Ontario (ESLO) Derby. This four-day event conducted along the entire New York shoreline each spring has typically had more than 10,000 salmonids entered. Derby organizers agreed to distribute a GLFC one-page request to solicit voluntary angler donations of lamprey specimens at the check stations. In addition, incidence of sea lampreys attached on salmonids represented in the DEC boat fishery census (LeTendre, et al 1989) is systematically measured.

III. Spawning-Phase Sea Lamprey Indices

The following procedures to assess abundance of spawning-phase sea lamprey have been described in a number of Lake Ontario Committee reports.

A. Lamprey Nest Counts have been documented in standardized sections of New York tributaries since 1971.

B. Assessment Traps and Mechanical Weirs have been operated in recent years by DFO and FWS on a number of Ontario and New York tributaries including some on which nest counts are also conducted.

C. Length, Weight and Sex Ratio of spawning phase sea lampreys collected in the above efforts, as well as from chemical treatments, are routinely recorded. These features have been shown to reflect stress induced by the chemical control program targeted at upper Great Lakes sea lamprey populations.

RESULTS

I. Wounding

Tables 1 through 8 depict most of the wounding available from stratified Lake Ontario salmonid samples. Generally, the 1988 data points represent a continuation of the trend to low wounding levels that has occurred over the last several years. Beyond that overall favorable picture, only a few minor comments seem worthwhile. One is that wounding in the Niagara area has recently become similar to that in areas to the east, as reflected by DEC September lake trout samples (Table 4). An examination of stage A_4 lamprey marks from those samples tended to strengthen this trend, after wounding in the Niagara area had remained convincingly lower than that in the eastern areas for a number of years. It is possible that two new sea lamprey infestations west of Rochester were responsible for the recent relative elevation in Niagara area wounding. If so, the 1988 treatment of those new infestations could cause wounding in the Niagara area to decline.

Data in Tables 7 and 8 were generated by new systematic salmonid sampling initiatives by OMNR which are expected to be extended to the entire Canadian coast in the future.

II. Parasitic Phase Sea Lampreys

Parasitic phase sea lampreys solicited from the spring ESLO Derby show a decrease to the lowest level yet observed in 1988 (Table 9). It can be seen that the number of fish entered in the Derby was also the smallest yet observed, owing to change in the Derby rules and a general trend toward offshore fishing which results in fewer but larger salmonids - especially chinook salmon. Even so, the decline in lampreys turned in in 1988 seems real. While total numbers of lampreys in the 1988 sample is very small, there is a suggestion of larger numbers to the west which is somewhat in agreement with recent wounding on lake trout. The Derby people did not have the numbers of fish entered in each check station for 1988.

The number of parasitic phase sea lampreys estimated from the DEC boat fishery census (LeTendre, et al 1989) was 1,568 in 1988 compared with 3,515 in 1987 and 3,309 in 1986. In terms of numbers of lampreys per 1000 salmonids caught, 1988 represented a reduction by nearly 50% from 1987 and 1986.

Similarly, systematic bottom trawling in fall 1988 detected a decline in estimates of lake trout carcasses bearing sea lamprey wounds (C.P. Schneider, personal communication).6/ That sampling may provide the most pertinent single index of sea lamprey induced impact in Lake Ontario.

III. Spawning-Phase Sea Lamprey Indices

A. Nest Counts

This effort produced unclear results again in 1988. Notable was an apparent sharp increase in Orwell, Trout, John O'Hara and Beaverdam Brooks (see Table 10) which are all tributaries of Salmon River so this could simply be an effect of a larger relative spawning run in Salmon River. On other contiguous Lake Ontario tributaries where counts were not precluded by chemical treatments, counts were similar to other recent years. Counts on the single Oneida Lake tributary (W. Br. Fish Cr.) have remained

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6/ NYDEC, Cape Vincent, NY

consistently low before and after lampricide treatments. This tends to support other evidence from pretreatment years that suggested a limited spawning population in spite of enormous production of parasitic phase animals from this sytem. In the Finger Lakes area, R. Engstrom-Heg[7] has reported a good correlation between nest counts in Catharine Creek and small wounds on brown trout from Seneca Lake the previous spring. That along with earlier results in Lake Ontario, tends to vouch for the validity of nest counts as an index of sea lamprey spawning runs.

B. Dam Traps and Portable Assessment Traps

Results of these efforts are unclear again in 1988 (Table 11). Numbers in Canadian traps are generally substantially greater than those in New York traps, possibly because the majority of the Canadian traps are permanent and more efficient devices and closer to the lake. Catches in the New York traps are the lowest to date in 1988, and for a few streams there appears to have been a genuine decline in recent years. Flows in many of these streams were relatively low in spring 1988 which could have affected upstream migration, particularly in New York.

C. Length, Weight and Sex Ratio

Sizes of Lake Ontario sea lampreys have remained essentially unchanged since they increased in the mid 1970's as an apparent response to the decrease in the lamprey/salmonid ratio. Sex ratio has persisted with a male dominance, failing to show stress from control efforts by shifting toward femaleness as has been exhibited by upper Great Lakes sea lampreys (Heinrich, et al 1980).

CONCLUDING REMARKS

The 1987 retreatment of Black River and the 1988 initial treatment of two new sea lamprey infestations west of Rochester were expected to result in a continuation and possibly further improvement in the favorable lamprey/salmonid balance that has followed initial lampricide treatments in the Oneida Lake watershed. In 1988 there may, indeed, have been further improvement. However, the planned retreatment of the Fish Creek system had to be abandoned in 1988 because of high flows that developed while the treatment unit was on site. Since this system is the primary Oneida Lake sea lamprey producer and surveys documented the presence of numerous animals undergoing metamorphosis in 1988 (D. Cuddy, pers. communication),[8] it is quite possible that a detectable resurgence of parasitic phase sea lampreys will occur in Lake Ontario in 1989. If this happens, it should not seriously reverse the recent favorable balance and lake trout survival noted above because 1), it will prevail for only a single season if Fish

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[7] DEC, Stamford, NY

[8] DFO, Sault Ste. Marie, Ontario

Creek is successfully treated in 1989 and 2), the substantially expanded lake trout population should be able to sustain the temporary sea lamprey increase without major impact. Indices will be closely watched for evidence of a surge in sea lampreys in 1989.

A more far-reaching threat to the lampricide program has come into being that poses serious consequences not only to the lake trout rehabilitation program but to the fabulously valuable salmonid sport fishery that has developed in Lake Ontario. As outlined in a comprehensive analysis by a cooperative effort of Great Lakes conservation agencies (Com W, 1989), the Great Lakes Fishery Commission is faced with a funding shortfall beginning in FY 1990 that would result in a 40% cutback in present sea lamprey control effort on Lake Ontario. Extended longterm, this would precipitate substantial and damaging resurgence of sea lampreys. The primary purpose of the above analysis is to inform pertinent people of the essential elements in the Great Lakes fisheries supported by sea lamprey control. The ultimate intent is to have appropriate GLFC funding provided. If successful and sea lamprey control effort on Lake Ontario is maintained at an aggressive level, the long term outlook for a favorable lamprey/salmonid balance is very good.

REFERENCES

Commmittee of the Whole (Com W). 1989. Economic Threat: Great Lakes Sport and Commercial Fishing Industries Face $1.4 Billion Annual Economic Losses Beginning 1990. Manuscript 15 pp. by an Operational Subcommittee of Com W, Great Lakes Fishery Commission.

Heinrich, J.W., J.G. Weise, and B.R. Smith, 1980. Changes in biological characteristics of the sea lamprey (Petromyzon marinus) as related to lamprey abundance, prey abundance, and sea lamprey control. Can. J. Fish. Aquat. Sci. 37: 1861-1871.

King, E.L., Jr. and T.A. Edsall. 1979. Illustrated field guide for the classification of sea lamprey attack marks on Great Lakes lake trout. GLFC Spec. Pub. 79-1, Ann Arbor, Michigan.

LeTendre, G.C., T.H. Eckert and C.P. Schneider. 1989. Summary of New York's Lake Ontario Fishing Boat Census, 1985-1988. Report to Lake Ontario Committee, March 1989, Grand Island, New York.

Schneider, C.P., T.H. Eckert, J.H. Elrod, R. O'Gorman, R.W. Owens, W. Dentry, T. Stewart, J.E. Marsden and C.C. Krueger. 1988. Lake trout rehabilitation in Lake Ontario, 1987. Report to Lake Ontario Committee, March 1988, Gananoque, Ontario.

TABLE 1. Sea lamprey wounding rates for adult coho taken by OMNR from the Credit River in the fall, Lake Ontario, Canada. Wounds: Stages I and II; Scars: Stages III and IV and Type B.

Year	n	Mean Fork Length mm (in)	Mean Total Length mm (in)	Weight g (lb)	# Wounds per Fish	% Wounding	# Scars per Fish	% Scarring	Total Marks per Fish	% Marking
1970	126	576 (22.7)	612 (24.1)	2291 (5.1)	3.02	92.9	3.29	96.8	6.31	100.0
1971	367	591 (23.3)	627 (24.7)	2250 (4.9)	2.16	77.7	3.62	96.7	5.77	99.5
1972	439	584 (23.0)	608 (23.9)	2358 (5.2)	1.01	66.5	3.21	95.9	4.23	98.6
1973	163	587 (23.1)	620 (24.4)	2461 (5.4)	0.96	60.1	2.02	83.4	2.98	92.0
1974	1726	646 (25.4)	658 (25.9)	3650 (8.0)	1.18	69.4	3.27	93.2	4.45	97.8
1975	921	669 (26.3)	708 (27.9)	3954 (8.7)	0.73	50.1	1.29	73.4	2.02	90.2
1976	304	680 (26.8)	723 (28.5)	4439 (9.8)	0.50	38.2	1.16	65.1	1.66	76.6
1977	345	664 (26.1)	701 (27.6)	4074 (9.0)	0.07	6.7	0.16	14.2	0.23	20.0
1978	310	684 (26.9)	727 (28.6)	4593(10.1)	0.05	4.8	0.24	18.4	0.29	22.6
1979	513	704 (27.7)	744 (29.3)	5392(11.9)	0.05	5.1	0.24	18.1	0.30	21.6
1980	312	658 (25.9)	ND	4200 (9.3)	0.06	4.8	0.14	12.5	0.21	17.3
1981	130	654 (25.7)	ND	4590(10.1)	0.02	2.3	0.06	4.6	0.09	6.2
1982	559	672 (26.5)	ND	4499 (9.9)	0.05	4.8	0.07	6.4	0.12	10.9
1983	342	692 (27.2)	732 (28.8)	4600(10.1)	0.003	0.3	0.05	4.4	0.06	4.7
1984	314	651 (25.6)	ND	4016 (8.8)	0.02	1.6	0.05	5.1	0.07	6.7
1985	282	677 (26.7)	718 (28.3)	4500 (9.9)	0.01	1.4	0.03	2.8	0.04	4.2
1986	332	664 (26.1)	705 (27.8)	3605 (7.9)	0.003	0.3	0.02	2.1	0.02	2.4
1987	354	668 (26.3)	713 (28.1)	4207 (9.3)	0.01	1.1	0.01	1.4	0.03	2.5
1988	280	680 (26.8)	723 (28.5)	4379 (9.7)	0.01	1.4	0.03	3.2	0.05	4.6

TABLE 2. Sea lamprey lesions on coho and chinook salmon collected during the fall spawning migration from Salmon River, New York. Samples were collected by estuarial gill netting and creel census with Salmon River Hatchery processing added in 1983.

	Sample Year	Average Total Length Inches (mm)	Type A Stages II-IV & Type B (Scars) Per Fish	Type A Stage I (Wounds) per Fish	Total Marks per Fish	Incidence of Attack %	Sample size
Chinook I+	1971	22.1 (561)	5.71	0.43	6.14	100	7
	1972	22.2 (564)	4.59	0.30	4.89	98	277
	1973	21.9 (556)	1.42	0.15	1.57	70	347
	1974	22.8 (579)	0.78	0.09	0.87	51	253
	1975	23.9 (607)	0.39	0.11	0.50	34	90
	1976	25.0 (635)	0.39	0.04	0.43	32	167
	1977	24.6 (625)	0.21	0.03	0.24	14	66
	1979	22.7 (577)	0.20	0.00	0.20	20	15
	1980	24.8 (631)	0.25	0.08	0.34	25	12
	1981	25.1 (638)	0.082	0.00	0.08	8	159
	1982	24.9 (633)	0.14	0.00	0.14	13	121
	1983	24.7 (627)	0.027	0.00	0.027	3	75
	1984	24.3 (617)	0.039	0.00	0.039	4	208
	1985	25.0 (634)	0.019	0.002	0.021	2	580
	1986	23.9 (608)	0.022	0.00	0.022	2	273
	1987	24.2 (614)	0.013	0.00	0.013	1	232
	1988	23.7 (602)	0.0078	0.00	0.0078	1	128
Coho II+	1971	24.4 (620)	9.28	0.59	9.86	100	53
	1972	23.5 (597)	7.19	1.00	8.19	96	53
	1973	23.6 (599)	3.11	0.30	3.41	89	123
	1974	26.2 (666)	2.08	0.75	2.85	93	71
	1975	28.2 (716)	1.37	0.57	1.94	82	192
	1976	28.1 (714)	1.69	0.39	2.07	82	67
	1977	29.5 (749)	0.50	0.06	0.56	41	270
	1978	29.2 (742)	0.65	0.06	0.71	51	271
	1979	29.0 (737)	0.58	0.01	0.59	42	80
	1980	31.0 (788)	0.73	0.13	0.86	58	106
	1981	29.7 (756)	0.29	0.03	0.32	26	34
	1982	29.4 (746)	0.56	0.05	0.61	41	39
	1983	27.8 (707)	0.054	0.0045	0.059	5	222
	1984	27.6 (701)	0.058	0.00	0.058	6	121
	1985	28.1 (715)	0.057	0.002	0.059	6	630
	1986	27.4 (697)	0.042	0.00	0.042	4	578
	1987	27.8 (706)	0.11	0.009	0.12	11	234
	1988	28.0 (711)	0.062	0.0	0.062	5	385

TABLE 3. Incidence of any type of sea lamprey attack on age II coho salmon and brown trout taken in the spring in nearshore Canadian and U.S. waters of Lake Ontario. Canada (OMNR) samples were collected by gill nets in the Niagara area. U.S. (DEC) samples were by gill netting from 1974 to 1978 and 1983, combination of gill netting and sport derby monitoring 1979 to 1981, a sport derby alone in 1982, 1984, 1985, 1986, and 1987, and a sport fishery grab sample in 1988. OMNR coho sampling at Niagara was discontinued after 1984.

		Percent Attacked (Sample Size)														
Source	Species/ Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
OMNR	Coho II	ND	29.4 (909)	14.9 (827)	2.9 (350)	1.4 (511)	3.7 (512)	2.8 (505)	1.6 (382)	10.3 (458)	1.0 (491)	3.1 (455)	NA	NA	NA	NA
DEC	Coho II	41.5 (371)	34.0 (282)	22.7 (128)	4.9 (81)	5.2 (347)	5.7 (856)	7.0 (2215)	4.1 (483)	11.4 (334)	2.9 (173)	2.9 (633)	2.3 (865)	1.4 (561)	1.6 (126)	1.6 (245)
DEC	Brown Trout II	45.2 (168)	46.7 (210)	29.7 (219)	21.7 (258)	21.6 (496)	29.2 (1262)	32.9 (2377)	23.5 (3277)	19.4 (4455)	12.8 (290)	4.5 (668)	7.6 (1336)	5.0 (1274)	8.3 (315)	0.0 (83)

Table 4. Number of Type A Stage I, II and III wounds per 100 lake trout for four size groups* and four geographic zones in Lake Ontario. Sample sizes in parenthesis. U.S. waters, gill net, September.

Year	GEOGRAPHICAL ZONE															
	Niagara				Rochester				Oswego				East. Basin			
	Size Group				Size Group				Size Group				Size Group			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1978	5.0 (121)	17.5 (97)	25.0 (8)	-	-	-	-	-	11.1 (9)	41.2 (17)	66.7 (3)	-	10.2 (59)	29.7 (74)	22.6 (53)	-
1979	3.0 (33)	19.5 (87)	33.3 (12)	-	2.7 (37)	15.6 (77)	12.5 (8)	-	10.0 (10)	50.8 (59)	58.3 (24)	-	28.6 (14)	23.3 (116)	37.8 (90)	42.9 (7)
1980	1.5 (66)	24.1 (29)	50.0 (16)	-	9.1 (22)	14.3 (7)	0 (4)	-	33.3 (30)	33.3 (6)	33.3 (9)	-	13.8 (29)	29.9 (67)	30.7 (127)	13.3 (15)
1981	4.5 (44)	14.8 (81)	22.2 (9)		4.0 (25)	8.3 (24)	-	-	0 (26)	35.1 (57)	41.7 (12)	-	2.3 (43)	17.5 (63)	12.0 (75)	8.0 (25)
1982	6.0 (151)	26.8 (82)	50.0 (28)	-	13.3 (30)	23.3 (43)	40.0 (20)	-	4.2 (48)	58.0 (50)	88.2 (34)	-	11.1 (27)	38.3 (60)	78.0 (59)	52.4 (21)
1983	2.9 (136)	9.9 (203)	37.8 (90)	-	2.2 (46)	18.4 (125)	31.8 (66)	66.7 (3)	2.4 (123)	26.2 (172)	58.7 (109)	-	0 (65)	15.1 (106)	36.1 (72)	7.7 (39)
1984	0 (168)	5.7 (122)	28.5 (151)	0 (8)	1.5 (65)	16.3 (86)	22.7 (76)	0 (3)	3.0 (100)	9.8 (112)	44.5 (119)	50.0 (8)	0 (23)	9.5 (95)	21.6 (88)	14.0 (43)
1985	0 (100)	5.7 (122)	17.8 (157)	0 (9)	0 (60)	37.3 (110)	52.8 (127)	169.2 (13)	2.0 (49)	29.5 (61)	80.6 (93)	145.5 (11)	3.4 (29)	24.0 (104)	53.1 (162)	62.5 (16)
1986	2.0 (152)	3.5 (113)	15.8 (291)	18.5 (54)	1.3 (80)	11.0 (100)	28.6 (217)	42.6 (35)	0 (47)	12.7 (79)	44.1 (227)	85.7 (49)	0 (27)	11.5 (87)	37.6 (229)	27.6 (29)
1987	0 (107)	4.0 (101)	17.4 (195)	25.6 (39)	0 (48)	0.9 (105)	42.9 (112)	67.6 (37)	0 (43)	9.2 (109)	34.2 (202)	79.1 (43)	0 (35)	16.5 (115)	39.4 (246)	34.9 (43)
1988	1.9 (103)	5.3 (113)	24.8 (226)	25.6 (43)	0 (66)	1.1 (93)	45.5 (198)	42.9 (35)	0 (41)	2.6 (78)	21.3 (183)	21.4 (42)	0 (56)	16.5 (131)	27.5 (189)	35.1 (74)

* Size Group Legend 1 = 431 - 531 mm (17.0 - 20.9 inches); 2 = 532 - 633 mm (21.0 - 24.9 inches);
3 = 634 - 735 mm (25.0 - 28.9 inches); 4 = 736 mm and over (29.0 + inches)

TABLE 5. Sea lamprey wounds and scars on lake trout taken in July from Canadian water of Eastern Outlet Basin, Lake Ontario. Wound is Stage I, Scar is Stage II-IV.

Size Class fork length mm	Year	Number of fish	CUE[a]	Number wounded	Freq. wounds	Wounds/ 100 fish	Wound[b] index	Number scarred	Freq. scars	Scars/ 100 fish	Scar[c] index
305-405 mm (12-15.9 in)	1977	8	0.7	0	0	0	0	0	0	0	0
	1978	75	6.3	1	1	1.3	0.1	1	1	1.3	0.1
	1979	63	5.9	2	2	3.2	0.2	1	1	1.6	0.1
	1980	58	2.4	0	0	0	0	0	0	0	0
	1981	98	1.9	0	0	0	0	0	0	0	0
	1982	44	7.8	0	0	0	0	0	0	0	0
	1983	201	26.7	1	1	0.5	0.1	4	4	2.0	0.5
	1984[d]	22	22.0	0	0	0	0	0	0	0	0
	1985	93	16.0	0	0	0	0	1	1	1.1	0.2
	1986	143	25.3	1	3	2.1	0.5	0	0	0	0
	1987	131	24.1	0	0	0	0	0	0	0	0
	1988	124	21.2	0	0	0	0	0	0	0	0
406-507 mm (16-19.9 in)	1977	41	3.4	2	3	7.3	0.3	6	8	19.5	0.7
	1978	83	6.9	6	6	7.2	0.5	6	9	10.8	0.8
	1979	125	11.7	5	5	4.0	0.5	14	16	12.8	1.5
	1980	90	16.3	2	2	2.2	0.4	12	12	13.3	2.2
	1981	145	9.0	1	1	0.7	0.1	9	10	6.9	0.6
	1982	77	13.2	4	4	5.2	0.7	5	8	10.4	1.4
	1983	207	28.0	0	0	0	0	20	20	9.7	2.7
	1984[d]	82	85.0	0	0	0	0	1	1	1.2	1.0
	1985	196	34.2	2	3	1.5	0.5	6	7	3.5	1.2
	1986	163	28.2	1	1	0.6	0.2	0	0	0	0
	1987	147	27.1	0	0	0	0	2	2	1.4	0.4
	1988	113	19.3	0	0	0	0	1	1	0.9	0.2
507-609 mm (20-23.9 in)	1977	7	0.6	0	0	0	0	1	1	14.3	0.1
	1978	9	0.8	1	1	11.1	0.1	3	6	66.7	0.5
	1979	61	5.1	6	6	9.8	0.5	16	20	32.8	1.7
	1980	116	21.1	11	12	10.3	2.2	44	50	43.1	9.1
	1981	102	7.8	1	1	1.0	0.1	26	35	34.3	2.7
	1982	37	6.2	1	1	2.7	0.2	14	18	48.7	3.0
	1983	193	25.1	16	16	8.3	2.1	96	137	71.0	17.8
	1984[d]	140	140.0	3	5	3.6	5.0	7	11	7.9	11.0
	1985	438	79.5	19	19	4.3	3.5	136	194	44.3	35.2
	1986	251	44.3	12	12	4.8	2.1	32	40	15.9	7.1
	1987	116	21.4	1	1	0.9	0.2	84	109	94.0	20.1
	1988	206	35.1	2	3	1.5	0.5	36	50	24.3	8.5

TABLE 5. Continued

Size Class fork length mm	Year	Number of fish	CUE[a]	Number wounded	Freq. wounds	Wounds/ 100 fish	Wound[b] index	Number scarred	Freq. scars	Scars/ 100 fish	Scar[c] index
610-711 mm (24-27.9 in)	1977	0	0								
	1978	0	0								
	1979	2	0.2	0	0	0	0	0	0	0	0
	1980	6	1.0	2	2	33.3	0.3	2	2	33.3	0.3
	1981	12	0.8	0	0	0	0	3	3	25.0	0.2
	1982	8	1.3	1	1	12.5	0.2	4	6	75.0	1.0
	1983	7	0.8	0	0	0	0	7	11	157.1	1.2
	1984[d]	22	22.0	1	2	9.1	2.0	5	9	40.9	9.0
	1985	93	16.0	9	10	10.8	1.7	59	117	125.8	20.1
	1986	82	14.2	12	13	15.9	2.3	30	38	46.3	6.6
	1987	246	45.3	0	0	0	0	78	146	59.3	26.9
	1988	102	17.4	1	1	1.0	0.2	55	86	84.3	14.7

a CUE - catch per 100 yards of 1½-6 inch mesh, ½ inch intervals by size class

b Wound index - wounds/fish x CUE

c Scar index - scars/fish x CUE

d 1984 - one lift only (Area IV)

TABLE 6. Lake Trout Wounding (Stage I) and Scarring (Stages II, III, and IV) August Cruise (Eastern Outlet), Canada.

Size Class fork length	Year	# of fish	CUE[a]	# wounded	% wounded	# of wounds	Wounds/ 100 fish	Wound[b] index	# scarred	% scarred	# of scars	Scars/ 100 fish	Scar[c] index
305-405 mm (12-15.9 in)	1978	59	5.5	1	1.7	1	1.7	0.1	0	0.0	0	0	0
	1979	22	1.9	0	0.0	0	0	0	0	0.0	0	0	0
	1980	10	1.8	0	0.0	0	0	0	0	0.0	0	0	0
	1981	25	5.0	0	0.0	0	0	0	0	0.0	0	0	0
	1982	62	8.2	0	0.0	0	0	0	0	0.0	0	0	0
	1983	63	13.8	0	0.0	0	0	0	0	0.0	0	0	0
	1984	68	12.6	0	0.0	0	0	0	0	0.0	0	0	0
	1985	85	16.7	0	0.0	0	0	0	0	0.0	0	0	0
	1986	90	18.6	0	0.0	0	0	0	1	1.1	1	1.1	0.2
	1987	61	11.7	0	0.0	0	0	0	0	0.0	0	0	0
	1988	4	0.8	0	0.0	0	0	0	0	0.0	0	0	0
406-507 mm (16-19.9 in)	1978	96	9.8	8	8.3	11	11.5	1.1	1	1.0	1	1.0	0.1
	1979	69	5.8	9	13.0	9	13.0	0.8	5	7.3	6	8.7	0.5
	1980	10	1.8	0	0.0	0	0	0	1	10.0	1	10.0	0.2
	1981	20	4.1	0	0.0	0	0	0	0	0.0	0	0	0
	1982	125	14.5	2	1.6	2	1.6	0.2	4	3.2	4	3.2	0.5
	1983	97	20.9	0	0.0	0	0	0	10	10.3	12	12.4	2.6
	1984	134	23.9	2	1.5	4	3.0	0.7	3	2.2	3	2.2	0.5
	1985	48	9.0	0	0.0	0	0	0	0	0.0	0	0	0
	1986	51	10.7	0	0.0	0	0	0	2	3.9	2	3.9	0.4
	1987	56	10.7	1	1.8	1	1.8	0.2	0	0.0	0	0	0
	1988	15	2.9	0	0.0	0	0	0	1	6.7	1	6.7	0.2
508-609 mm (20-23.9 in)	1978	8	0.7	0	0.0	0	0	0	2	25.0	2	25.0	0.2
	1979	36	3.1	5	13.9	6	16.7	0.5	14	38.9	17	47.2	1.4
	1980	27	5.4	1	3.7	1	3.7	0.2	12	44.4	20	74.1	4.0
	1981	32	6.3	0	0.0	0	0	0	6	18.8	10	31.3	2.0
	1982	86	10.3	1	1.2	1	1.2	0.1	39	45.3	65	75.6	7.8
	1983	178	39.0	7	3.9	8	4.5	1.8	106	59.6	161	90.5	35.3
	1984	286	52.0	12	4.2	14	4.9	2.6	79	27.6	101	35.3	18.4
	1985	185	32.8	1	0.5	1	0.5	0.2	61	33.0	86	46.5	15.3
	1986	161	36.9	10	6.2	10	6.2	2.3	28	17.4	35	21.7	8.0
	1987	373	71.3	9	2.4	14	3.8	2.7	133	35.7	184	49.3	35.2
	1988	61	11.8	0	0.0	0	0	0	6	9.8	16	26.2	3.1

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a CUE - catch per 100 yards of 1½-6 inch mesh, ½ inch intervals by size class
b Wound Index - Wounds/fish x CUE
c Scar Index - Scars/fish x CUE

TABLE 7. Sea lamprey wounds and scars on lake trout taken in 1.5-5.0 inch gill nets in midsummer from three transects in Kingston Basin Nearshore at six depths [2.5-27.5 M at 5 M intervals] Lake Ontario, Canada. Wound is stage I; Scar is stage II-IV.

Size Class Fork Length	Year	# of fish	CUE[a]	# wounded	Freq. wounds	Wounds/ 100 fish	Wound index[b]	# scarred	Freq. scars	Scars/ 100 fish	Scar index[c]
305-405 mm (12-15.9 in.)	1986	37	1.5	0	0	0	0	0	0	0	0
	1987	14	0.6	0	0	0	0	1	3	21.4	0.1
	1988	24	1.0	0	0	0	0	0	0	0	0
406-507 mm (16-19.9 in.)	1986	63	2.5	0	0	0	0	2	2	3.2	0.1
	1987	20	0.8	0	0	0	0	2	2	10.0	0.1
	1988	34	1.4	0	0	0	0	0	0	0	0
508-609 mm (20-23.9 in.)	1986	310	12.2	4	4	1.3	0.2	36	38	12.3	1.5
	1987	184	7.4	6	6	3.3	0.2	58	73	39.7	2.9
	1988	125	5.1	1	1	0.80	0.0	11	13	10.4	0.5
610-711 mm (24.27.9 in.)	1986	167	6.6	6	8	4.8	0.3	48	68	40.7	2.7
	1987	130	5.3	1	1	0.77	0.0	82	141	108.5	5.7
	1988	66	2.7	2	2	3.0	0.1	31	53	80.3	2.1

[a] CUE - catch per 100 yds of 1½-5 inch mesh, ½ inch intervals by size class
[b] Wound index - wounds/fish x CUE
[c] Scar index - scars/fish x CUE

TABLE 8. Sea lamprey wounds and scars on lake trout taken in 1.5 - 5.0 inch gill nets in midsummer from three transects on Prince Edward South Shores at six depths [2.5-27.5 M at 5 M intervals] in Central Basin, Lake Ontario, Canada. Wound is stage I; Scar is stage II-IV.

Size Class Fork Length	Year	# of fish	CUE[a]	# wounded	Freq. wounds	Wounds/ 100 fish	Wound index[b]	# scarred	Freq. scars	Scars/ 100 fish	Scar index[c]
305-405 mm (12-15.9 in)	1988	18	0.8	0	0	0	0	0	0	0	0
406-507 mm (16-19.9 in)	1988	69	3.2	0	0	0	0	0	0	0	0
508-609 mm (20-23.9 in)	1988	214	10.0	3	3	1.4	0.1	7	10	4.7	0.5
610-711 mm (24-27.9 in)	1988	73	3.4	1	1	1.4	0.1	10	17	23.3	0.8

[a] CUE - catch per 100 yds of 1½-5 inch mesh, ½ inch intervals by size class

[b] Wound index - wounds/fish x CUE

[c] Scar index - scars/fish x CUE

TABLE 9. ESLO spring sea lamprey collections, Lake Ontario. Voluntary specimen donations were solicited by GLFC and collected by NYDEC personnel during each 4-day derby. Stations listed in East to West order.

Check Station	# Derby Fish Collected						# Lampreys Turned In						# Lampreys per 1000 Derby Fish					
	1983	1984	1985	1986	1987	1988	1983	1984	1985	1986	1987	1988	1983	1984	1985	1986	1987	1988
Henderson	NO	NO	538	985	153	NA	-	-	5	7	4	1	-	-	9.3	7.1	26.1	-
Sandy Pond	1052	631	432	1096	115	NA	2	8	3	6	11	1	1.9	12.7	6.9	5.5	95.7	-
Mexico Point	NO	NO	NO	967	688	NO	-	-	-	6	7	-	-	-	-	6.2	10.2	-
Oswego	1010	783	580	599	538	NA	10	14	9	1	2	0	9.9	17.9	15.5	1.7	3.7	-
Fair Haven	1422	1303	1305	1141	515	NA	18	12	10	5	10	0	12.7	9.2	7.7	4.4	19.4	-
Sodus	2476	3252	1871	1442	1143	NA	33	22	18	12	11	1	13.3	6.8	9.6	8.3	9.6	-
Rochester	1236	2264	2132	1466	507 (313)	NA	6	27	16	13	7*	0	4.9	11.9	7.5	8.9	22.4	-
Braddocks	1009	2600	2370	1258	625	NA	6	NS	21	2	5	0	6.0	-	8.9	1.6	8.0	-
Oak Orchard	1178	1989	3467	1225	468	NA	7	19	35	6	3	3	5.9	9.6	10.1	4.9	6.4	-
Olcott	NO	NO	NO	649	508	NA	-	-	-	5	9	2	-	-	-	7.7	17.7	-
Wilson	2080	1749	2213	609	628	NA	13	42	19	2	18	4	6.3	24.0	8.6	3.3	28.7	-
Totals	11,463	14 571 (11,971)	14,908	14,473	5,978 (5,694)	2,657	95	144	136	65	87	12	8.3	12.0	9.1	5.7	15.3	4.5

* = Lamprey sample not collected the last 2 days of the derby at this station
NO = Station not operating
NS = No lamprey sample collected
NA = Not available
Derby dates: April 28-May 1, 1983; April 26-29, 1984; April 25-28, 1985; April 24-27, 1986; April 23-26, 1987; April 28-May 1, 1988

TABLE 10. Sea lamprey nest counts on standardized sections of contiguous Lake Ontario tributaries and a tributary of Oneida Lake, all in New York.

	Contiguous Lake Ontario Streams										Oneida Lake Tributary
	S. Sandy Cr.	Skinner Cr.	Lindsey Cr.	L. Sandy Cr.	Orwell Br.	Trout Br.	John O'Hara Br.	Beaverdam Br.	Grindstone Cr.	Sterling Cr.	W. Br. Fish Cr.
Section Length Miles	1.3	4.2	2.1	1.6	2.2	2.2	1.5	0.5	2.0	1.2	4.5
1971	ND	411	158	223	162	ND	ND	ND	97	73	ND
1972	ND	CT	CT	CT	CT	ND	ND	ND	CT	CT	ND
1973	ND	CT	CT	CT	CT	ND	ND	ND	CT	CT	ND
1974	ND	49	24	9	3	ND	ND	ND	11	49	ND
1975	ND	226	26	33	CT	ND	ND	ND	CT	CT	ND
1976	ND	EHW	EHW	EHW	EHW	ND	ND	ND	EHW	EHW	ND
1977	ND	272	81	89	25	ND	ND	ND	43	49	ND
1978	ND	392	42	106	CT	ND	ND	ND	107	82	ND
1979	ND	133*	36*	CT	31	ND	ND	ND	210**	CT	ND
1980	CT	CT	CT	44	82	ND	ND	ND	168	95	45
1981	84	EHW	EHW	42	CT	ND	ND	ND	377	233	30
1982	154	76	36	CT	15	ND	ND	ND	CT	CT	21
1983	836	CT	CT	139	CT	ND	ND	ND	493	206	24
1984	ND	122	68	136	12	ND	ND	ND	427	198	CT
1985	120*	92*	54*	CT	22	98	39	63	CT	CT	54
1986	141*	70*	55*	61	CT	CT	CT	CT	319	66	15*
1987	245	265	254	CT	10	31	15	1	CT	56	22
1988	155	CT	CT	125	241	273	146	189	315	CT	52

Legend:
ND = Not done
CT = Not done because of concurrent chemical treatments
EHW = Not done because of erosion by high water
* = Count possibly biased downward because of high water
** = Count possibly biased downward because of adults in PAT's were removed

TABLE 11. Numbers of spawning-run lampreys collected in Dam Traps (DT) and Portable Assessment Traps (PAT) operated under the direction of DFO and FWS in selected Ontario and New York tributaries of Lake Ontario, 1978-1988. New York catches were adjusted by spawning-run peaks and temperature to compensate for lampricide treatments during run. Adjusted numbers are in parenthesis.

Stream	Gear	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Ontario												
Graham Creek	(DT)	60**	168	160	32**	67	ND	26	672	122*	224**	94
Humber River	(DT)	ND	ND	104	608***	876	4625***	1366	2828	2069	4870	2,509
Bowmanville Creek	(PAT)	109*	62**	28*	182**	309	100	242	466	155*	641**	527
Wilmot Creek	(PAT)	14*	15**	67*	107**	80	566	9	58	93*	133**	44
Shelter Valley Cr.	(DT)	6**	152	12*	14**	144	ND	14*	123**	2531***	905**	1,015
Duffin Creek	(DT)	ND	ND	ND	293**	149	606	520	1059	615**	1320	1,094
Lakeport Creek	(DT)	ND	ND	ND	ND	ND	ND	ND	47	42	97	69*
TOTAL ONTARIO		-	-	-	1,236	1,625		2,177	5,253	5,627	8,190	5,352
New York												
Sterling Creek	(PAT)	ND	ND	28	125	361 (412)	174**	43	85 (141)	77**	25	41 (57)
Sterling Valley Cr.	(PAT)	ND	ND	324	218	422 (626)	461**	427	258 (427)	412**	304	125 (214)
Catfish Creek	(PAT)	65	360	29 (50)	11**	10	11	2	0**	2	1 (2)	0
Little Salmon R.	(PAT)	242	673 (910)	47**	113	316	7**	2	52	4**	1	3
Grindstone Ck.	(PAT)	315	623**	311	210	255 (350)	678**	138	70 (175)	69**	56 (69)	24
South Sandy Cr.	(PAT)	ND	ND	ND	ND	ND	ND	ND	1	10	114	0
TOTAL NEW YORK		-	1,656 (1,893)	739 (760)	677	1,364 (1,714)	1,331	602	466 (796)	574	501 (515)	193 (298)

* Stream treated with lampricide during spawning run
** Stream treated with lampricide the previous year
ND Not done
*** Trapping system modified and/or relocated

TABLE 12. Biological statistics of spawning-run sea lampreys captured by dip netting (N), weirs (W) and trapping (T) and by routine chemical treatments (CT) under contract to DFO and FWS in Humber River and other tributaries to Lake Ontario in Ontario and New York.

Humber River (N)

Year	Number Collected	Number Sampled	% Males	Mean Length Males	cm (in) Females	Mean Weight Males	g (oz) Females
1968	1221	1221	50.1	43.1 (17.0)	40.9(16.1)	164(5.8)	161(5.7)
1969	1335	1335	50.7	42.0 (16.5)	42.0(16.5)	170(6.0)	175(6.2)
1970	2185	2177	53.0	41.1 (16.4)	41.1(16.2)	156(5.5)	167(5.9)
1971	2450	1488	55.7	41.0 (16.1)	41.0(16.1)	155(5.5)	165(5.8)
1972	4615	4395	55.3	42.0 (16.5)	42.0(16.5)	149(5.3)	159(5.6)
1973	6308	5065	55.1	41.0 (16.1)	42.0(16.5)	157(5.5)	170(6.0)
1974	3350	2727	58.4	42.0 (16.5)	42.0(16.5)	166(5.9)	176(6.2)
1975	6848	1296	53.5	44.0 (17.1)	44.0(17.1)	187(6.6)	204(7.2)
1976	4030	885	56.9	46.0 (18.1)	45.0(17.7)	230(8.1)	239(8.4)
1977	1601	489	53.8	47.0 (18.5)	47.0(18.5)	240(8.5)	248(8.8)
1978	2453	339	42.0	44.0 (17.1)	45.0(17.7)	207(7.3)	224(7.9)
Ontario							
1977	- (T)	169	56.5	48.8 (19.2)	47.8(18.8)	271(9.6)	271(9.6)
1978	- (T&W)	326	48.0	48.0 (18.9)	47.0(18.5)	260(9.2)	237(8.4)
1979	- (T&W)	317	56.0	48.0 (18.9)	48.0(18.9)	272(9.6)	282(10.0)
1980	384(T&W)	353	55.0	49.0 (19.3)	49.3(19.3)	245(8.6)	253(8.9)
1981	1239(TW&N)	1239	58.0	47.0 (18.5)	47.0(18.5)	240(8.5)	247(8.7)
1982	1625(TW&N)	1440	53.4	49.0 (19.3)	48.0(18.9)	242(8.5)	244(8.6)
1983	5898(T)	2740	60.0	45.8 (18.0)	45.5(17.9)	217(7.7)	227(8.0)
1984	2177(T&W)	1081	55.0	49.4 (19.5)	48.4(19.1)	264(9.3)	267(9.4)
1985	5253(T&W)		63.2	48.6 (19.1)	47.8(18.8)	247(8.7)	249(8.8)
1986	5627(T&W)	1768	64.9	50.2 (19.8)	49.7(19.6)	267(9.4)	273(9.6)
1987	8190(T&W)	1711	61.0	49.4 (19.4)	48.4(19.1)	272(9.6)	269(9.5)
1988	5374(T&W)	1636	52.0	48.2 (19.0)	47.7(18.8)	259(9.1)	262(9.2)
New York							
1978	- (T)	211	52.1	--------46.4 (18.3)------		------226 (8.0)------	
1979	- (T)	1548	51.6	48.8 (19.2)	48.5(19.1)	262(9.2)	264(9.3)
1979	- (CT)	305	60.0	47.0 (18.5)	47.0(18.5)	262(9.2)	259(9.1)
1980	- (CT)	342	56.0	48.3 (19.0)	48.1(18.9)	254(8.6)	254(9.0)
1981	- (T)	212	61.0	47.8 (18.8)	48.6(19.1)	261(9.2)	263(9.3)
1982	1364(T)	1364	60.0	49.7 (19.6)	48.6(19.1)	255(9.0)	257(9.1)
1983	1331(T)	480	63.0	48.7 (19.2)	48.3(19.0)	243(8.6)	248(8.7)
1984	602(T)	431	56.0	49.3 (19.4)	48.5(19.1)	286(10.1)	282(9.9)
1985	466(T)	311	62.0	48.8 (19.2)	48.0(18.9)	269(9.5)	265(9.3)
1986	574(T)	525	68.0	49.1 (19.3)	48.7(19.2)	269(9.5)	268(9.5)
1987	501(T)	423	74.0	50.1 (19.7)	49.8(19.6)	212(7.5)	213(7.5)
1988	193(T)	123	66.0	42.8 (16.9)	41.6(16.4)	238(8.4)	234(8.3)

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GILLNET SELECTIVITY FOR LAKE TROUT

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ABSTRACT

Gillnet selectivity for lake trout in Lake Ontario was assessed using catches from the adult lake trout assessment program. The catch was biased towards large fish. Such bias has little effect on estimates of growth, but it has a potentially great effect on estimates of mortality rates.

RECOMMENDATION

Refine the selectivity estimates presented here, and use them to adjust estimates from the adult lake trout assessment program.

INTRODUCTION

The Ministry of Natural Resources is currently compiling and analyzing lake trout data collected largely by the assessment units around the province[1]. The investigative topics span all aspects of biology and management of the species. As a member of the group concerned with sampling methodology, I examined size specific gillnet selectivity, using Lake Ontario data collected in in the lake trout assessment program (Schneider et al., 1989).

Rehabilitation of lake trout in Lake Ontario is now reaching the stage where the population is close to the parameter values identified by Schneider et al. (1983) as prerequisite for a self-sustaining population (Schneider et al., 1989). The effect of gear selectivity on the estimates those parameters is therefore a timely subject. This report outlines the work done to date, although I feel that further refinements are needed.

1.

[1] Lake Trout Synthesis, document scheduled for completion in 1989.

SIZE CHARACTERISTICS OF THE CATCH

The traditionally assumed pattern of gillnet selectivity, where each mesh size optimally captures fish of a related size, is not apparent in the data from Lake Ontario. Instead, the length frequency distribution of fish from the small meshes is bimodal (Figure 1). As the mesh size increases the lower mode shifts upwards, and in the largest meshes it merges with the upper mode. Bimodal selectivity curve has been reported for walleye by Hamley and Regier (1973), with both modes shifting towards larger fish as the mesh size increased. In the case of lake trout in Lake Ontario, however the upper mode is stationary across all mesh sizes.

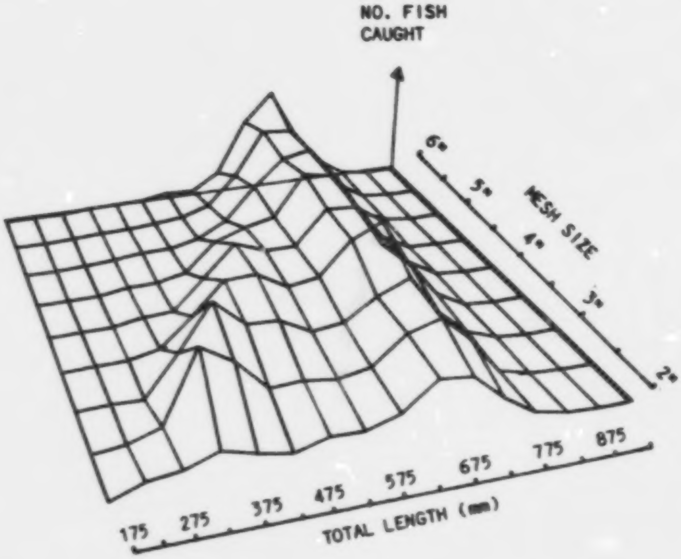

FIGURE 1. Total catch of lake trout by mesh size and by 50 mm size categories. Pooled data from 1983, 1985-87.

A bimodal selectivity curve suggests two modes of capture. Hamley and Regier separated the walleye into wedged and tangled fish, respectivelly corresponding to the lower and upper modes. To determine if this occurs in lake trout, I monitored the capture of 220 fish during the 1988 lake trout assessment program, separating the fish into tangled and wedged. The results (Figure 2) confirm that wedging corresponds to the lower mode of the length frequency distribution. Tangling corresponds to the upper mode consisting of large fish regardless of mesh size, although a some tangling of small fish also occurred in small meshes.

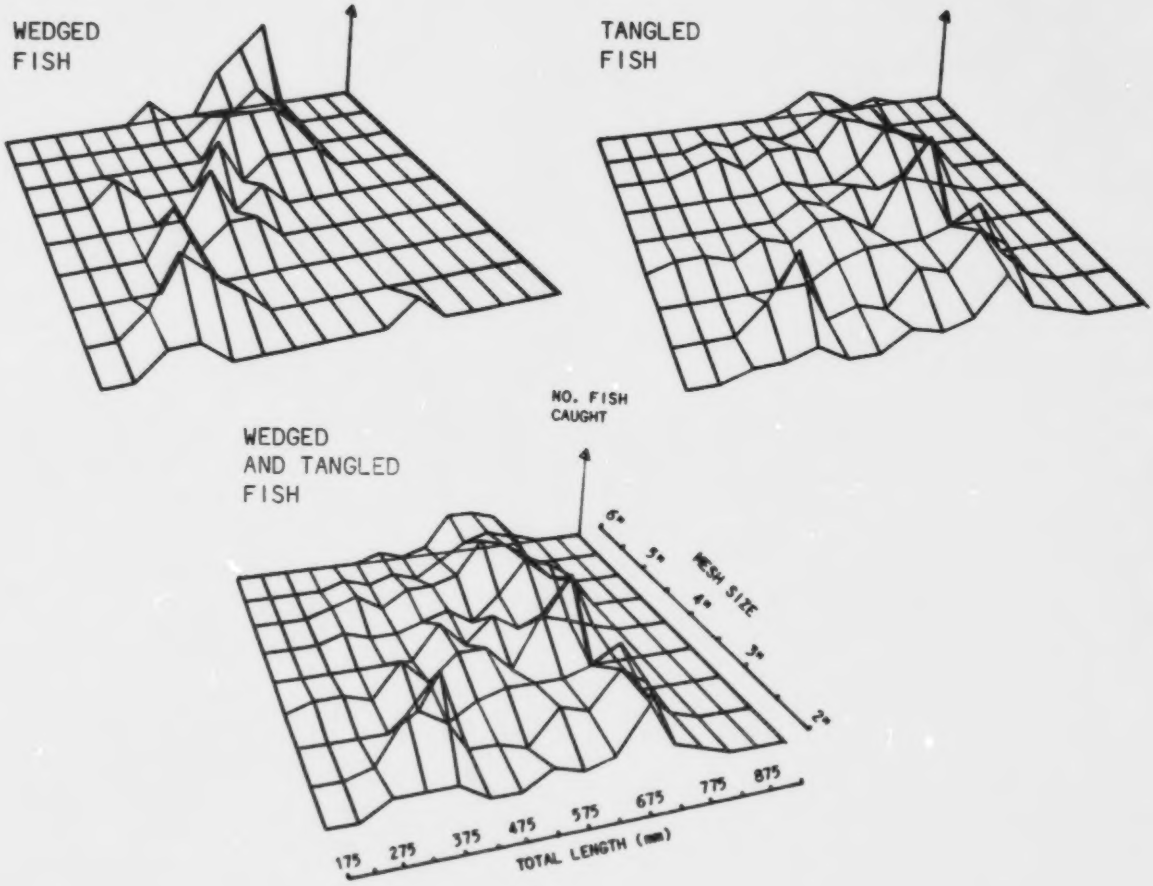

FIGURE 2. Catches of tangled and wedged fish by mesh size and by 50 mm size categories. Data from 220 fish caught in September 1988 during the lake trout assessment program.

SELECTIVITY

Size composition of captured fish is determined by the size composition of fish in the population, size dependent encounter probability, and size dependent retention probability. Selectivity is often defined as the combination of the latter two factors (Hamley, 1975), and thus it expresses the proportion of a size class that is retained in the gear.

Estimates of selectivity must involve knowledge of the size distribution of fish in the population, or make the assumption that the shapes and magnitudes of selectivity curves from various mesh sizes are equal (Hamley, 1975). Neither condition applies to the lake trout in Lake Ontario. The size characteristics of the population are not known; they can only be inferred from gillnet catches, but those are already biased by selectivity. Assumptions about the shape and magnitude of the selectivity curve are also difficult to make, since the general shape of the curve changes across mesh sizes as the lower distribution mode shifts upward.

I chose to make an assumption about mortality. Lake trout are stocked in known numbers, and it is possible to estimate the age structure at any point by assuming a mortality rate. The population age structure together with age and size composition of catch can then be combined to estimate the size selectivity of the gear used to capture the fish (Appendix A). The most critical and potentially erroneous assumption is that of the population age distribution, which in turn is derived from assumed mortality rates.

Only U.S. stocked lake trout were used in the calculations, since they bear coded wire tags providing unambiguous information on age and stocking origin. The fish were further restricted to those of the Clearwater Lake and Lake Superior strains stocked as spring yearlings from 1980 to 1984 (year classes 1979 to 1983), and recaptured in the adult lake trout assessment program from 1984 to 1987. To calculate the age structure of the population in any given year, I assumed that stocking mortality was unknown but constant across years, and that thereafter the fish were subject to the following mortalities: 60% in winters of 1980/81 through 1984/85, 49% in 1985/86, and 35% in 1986/87 (Schneider et al., 1988, Fig.6). This table of cohorts was used as input into the selectivity estimating procedure. Similar cohort tables were also constructed, using uniform high (60%) and low (40%) mortality rates in order to bracket the mortality assumption.

The results indicate that gillnet is highly selective for large lake trout. Figures 3 and 4 show the overall selectivity profiles for the multi-mesh gillnet used in the assessment program. In all cases the highest selectivity occurs around 700-800 mm total length, just below the upper size limit of captured fish. Calculations based on the two other mortality assumptions do not substantially change the conclusions; the greatest deviation occured when a low mortality rate was assumed, which likely resulted in overestimating the

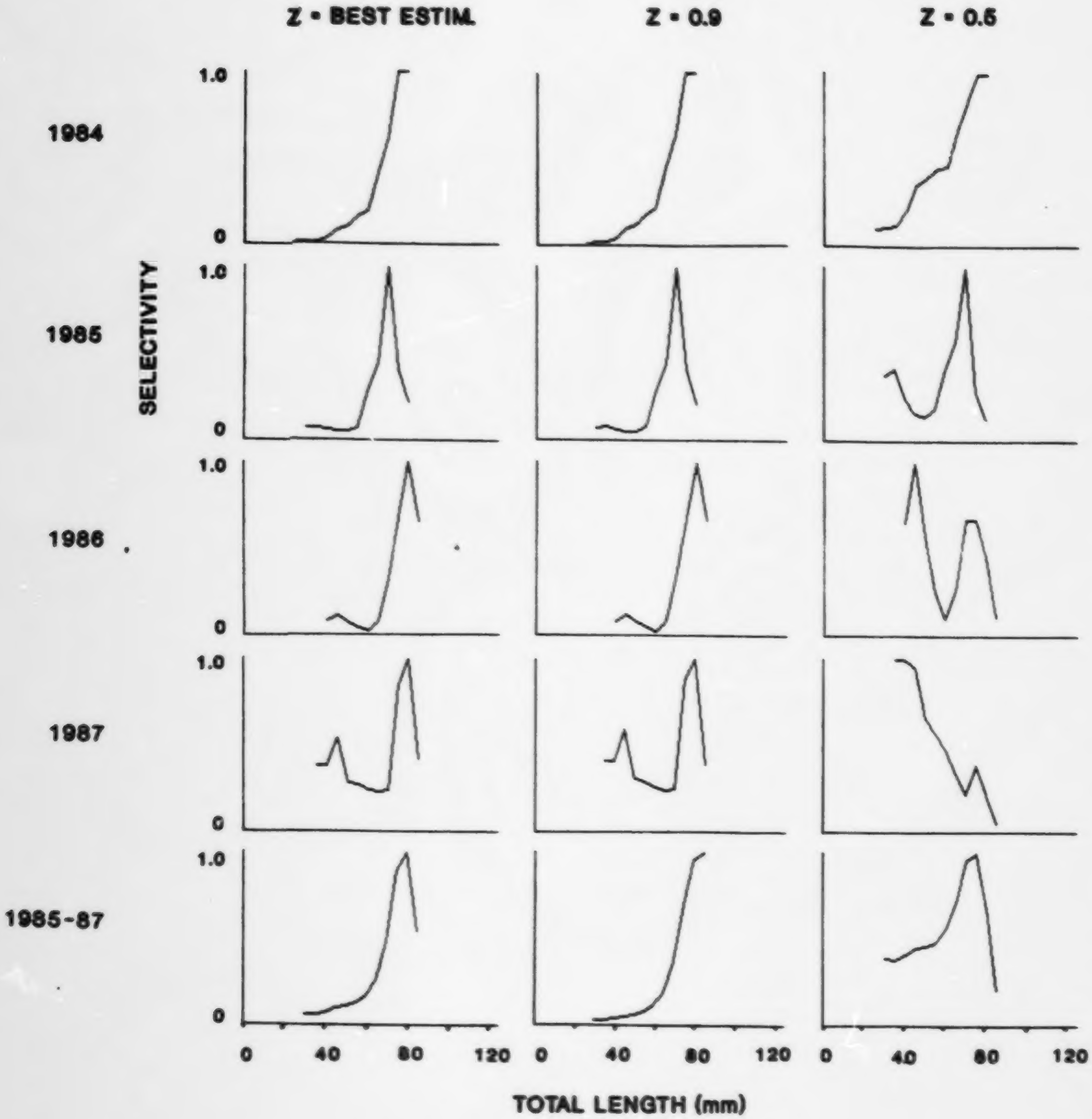

FIGURE 3. Selectivity profiles for multi-mesh gillnets estimated from Lake Superior strain fish caught in 1984 to 1987. The height of each graph was adjusted to have a maximum value of 1.0. The estimates were not corrected for unequal panel lengths. The data from 1984 are not included in the pooled calculations, because significanlty less fishing effort was used. The mortality rates refer to the assumptions made in order to estimate selectivity.

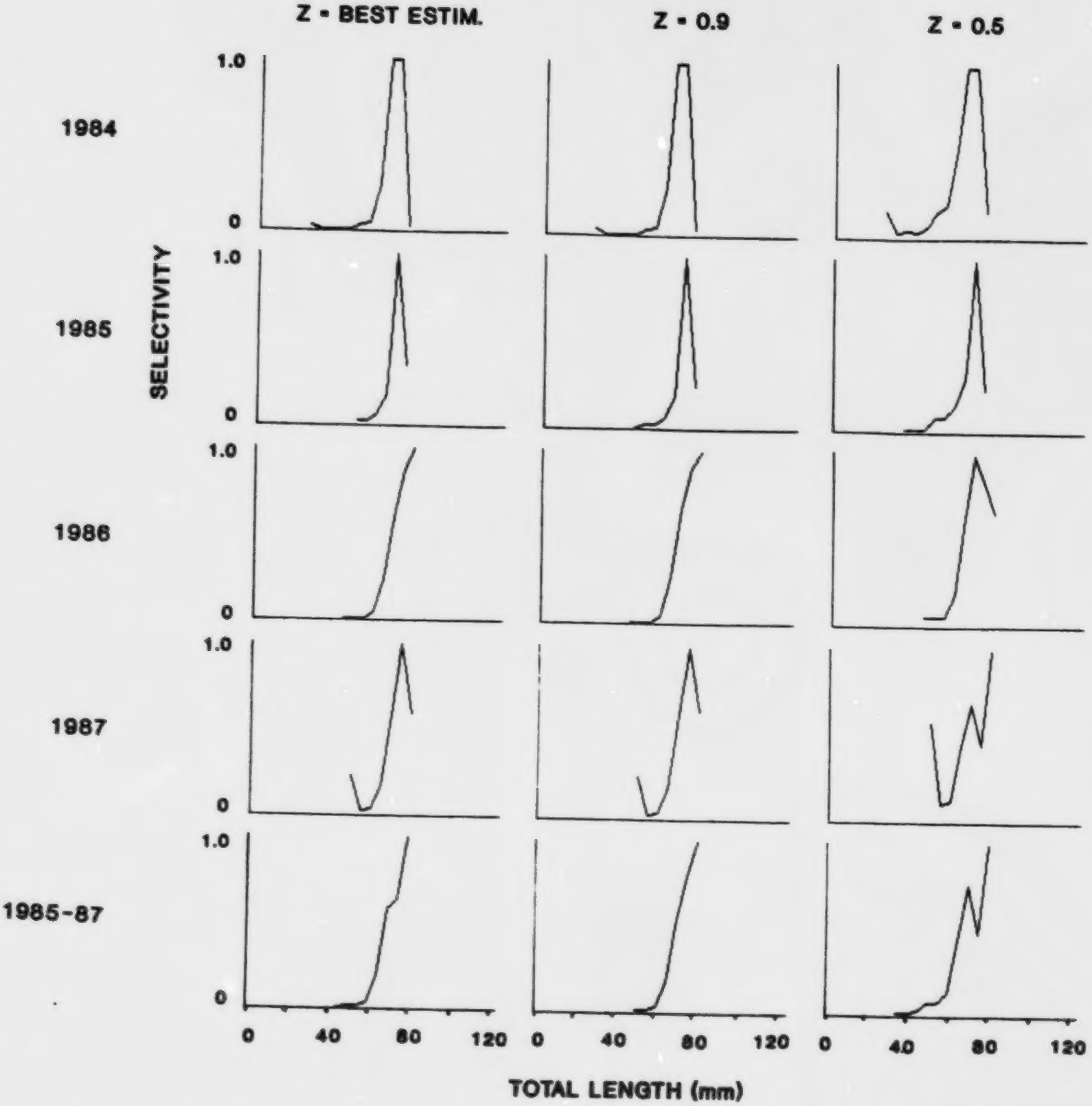

FIGURE 4. Selectivity profiles for multi-mesh gillnets estimated from Clearwater Lake strain fish caught in 1984 to 1987. The height of each graph was adjusted to have a maximum value of 1.0. The estimates were not corrected for unequal panel lengths. The data from 1984 are not included in the pooled calculations, because signficanlty less fishing effort was used. The mortality rates refer to the assumptions made in order to estimate selectivity.

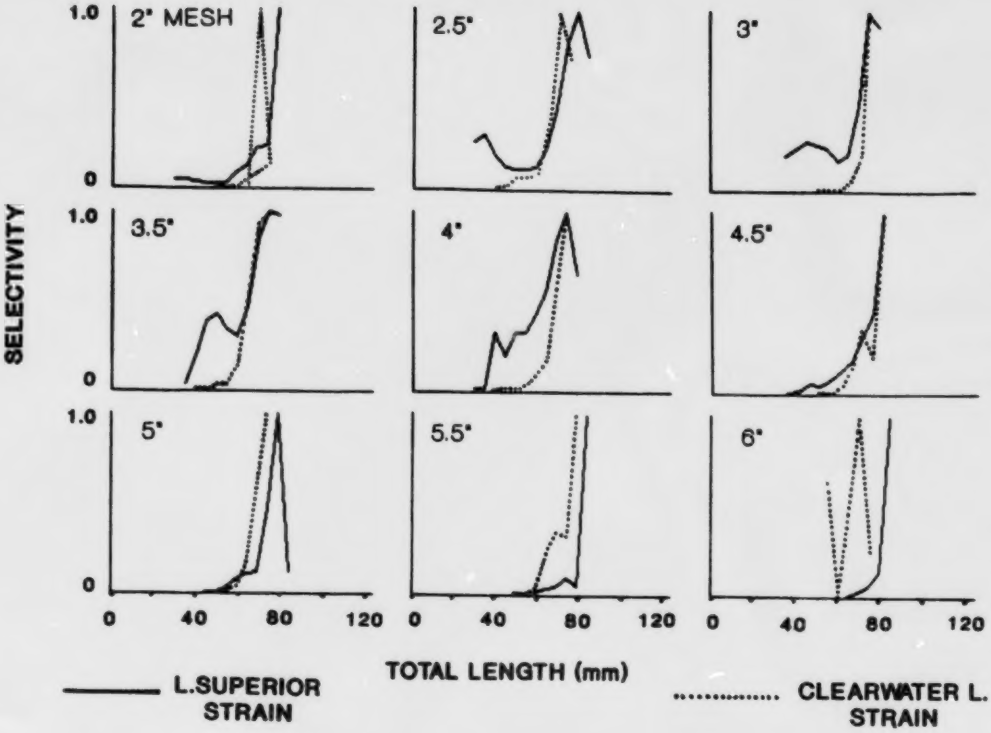

FIGURE 5. Selectivity profiles for individual mesh sizes, based on Lake Superior and Clearwater Lake strains, pooled 1985-87 data, using best mortality estimate to calculate input age structure (equivalent to bottom left curves in Figures 2 and 3).

numbers of available large old fish. In most cases selectivity appears to fall off in the largest fish, although with tangling there is no logical reason for this decrease. Furthermore, the confidence in the estimates for large fish is low because of the low number of available and captured fish.

All mesh sizes used for standard assessment select large fish (Figure 4). In the profiles from Superior fish there are secondary selectivity peaks for small fish in smal meshes, as would be expected from inspection of the total catch composition (Figure 1). No such peaks can be detected in the estimates from Clearwater fish. This discrepancy may be due to sampling error, but it may also be a reflection of some difference between the two strains. It was not pursued further, since in the selectivity profiles from the compund meshes, such secondary peaks are insignificant compared to the overall tendency to capture large fish.

CONSEQUENCES OF SELECTIVITY

The selectivity profile estimated from pooled 1985-87 Superior strain data was used as an example to simulate the effects of selective gear on estimates of growth and mortality. Selectivity was assumed to be zero for fish less than 275 mm. The rightmost descending limb of the profile was eliminated by assuming constant maximum selectivity for all fish larger than 775 mm, since the confidence in this region is low, and high selectivity for large fish appears more plausible. A polynomial curve approximating the 1985-87 Superior profile was fitted between these extremes. This selectivity curve was used in simulating catch from a known population whose parameters resembled those of Lake Ontario lake trout (Appendix B).

Selectivity does not greatly affect growth estimates (Figure 6). The greatest difference (34 mm) between estimated and true mean size occurs at age 5. Here the fish attain a length which is in the middle of the steep transition from low to high selectivity. The difference at older ages decreases as the fish grow to a size that is fully selected.

The effect of selectivity on the estimate of population age structure, and on subsequent estimate of mortality, is greater. Figure 7 shows the bias in catch curve due to selective gear. The population was simulated with a uniform instantaneous mortality rate of 0.9 per year (41% survival) throughout its life. The mortality estimate from the simulated catch curve varied depending on the range of ages chosen for the calculation. Using ages 2-10 yielded an estimate of annual instantaneous mortality rate of 0.53 (58% survival) while ages 6-10 yielded 0.79 (45% survival). As with the growth estimates, it appears that statistics involving the ages where the selectivity undergoes the greatest change, are subject to the greatest bias due to selectivity.

FURTHER WORK

Selectivity can critically bias the estimate of mortality rates, and should therefore be considered in the future. Assessment of selectivity is difficult, and the figures presented here could be improved through more careful choice of parameter values in estimation of selectivity, and in simulation of the effects.

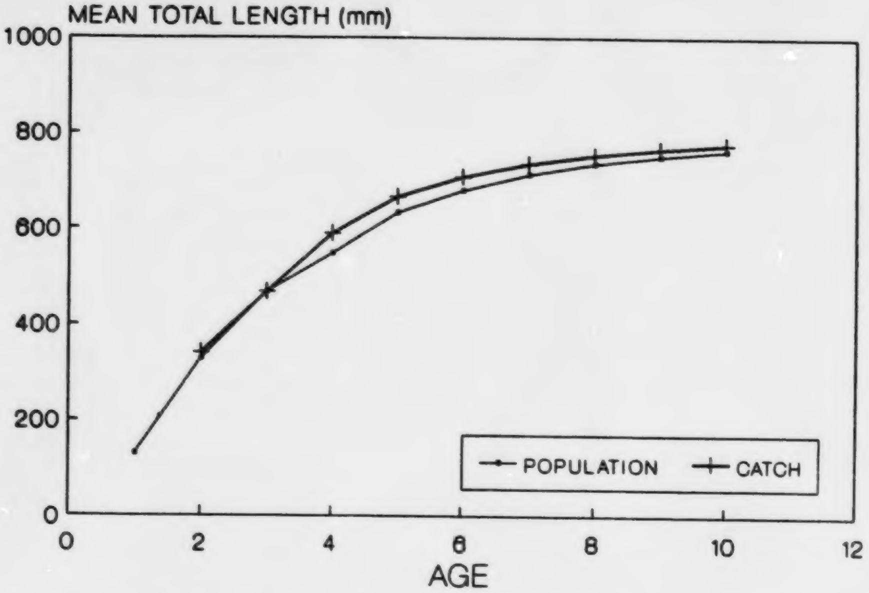

FIGURE 6. Effect of selectivity on estimated growth curve. Mean sizes in the simulated population are contrasted with those in the simulated catch.

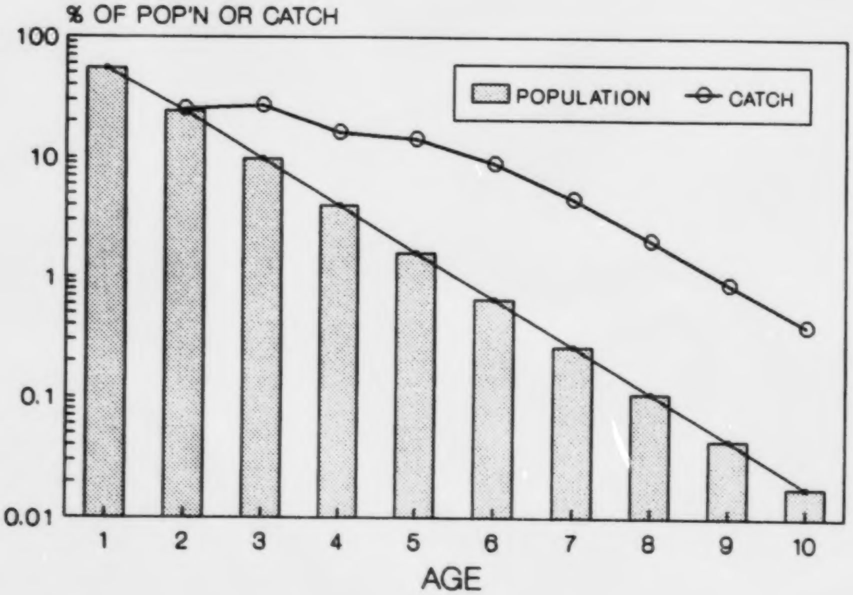

FIGURE 7. Effect of selectivity on estimates of population age structure and mortality. Age structure of the simulated population is contrasted with catch curve obtained from the simulated gear.

REFERENCES

HAMLEY, J.M.. 1975. Review of gillnet selectivity. J.Fish.Res.Board Can. 32:1943-1969.

HAMLEY, J.M., and H.A. REGIER. 1973. Direct estimates of gillnet selectivity to walleye (*Stizostedion vitreum vitreum*). J.Fish.Board Can. 30:817-830.

SCHNEIDER, C.P., T.H. ECKERT, J.H. ELROD, R. O'GORMAN, R.W. OWENS, W. DENTRY, J.E. MARSDEN, and C.C. KRUEGER. 1989. Surveillnace report for lake trout rehabilitation in Lake Ontario, 1988. *In* Lake Ontario Fisheries Unit 1988 Annual Report. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit, Picton, Ontario.

SCHNEIDER, C.P., D.P. KOLENOSKY, and D.B. GOLDTHWAITE. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario. Great Lakes Fishery Commission,Lake Ontario Committee, Spec. Publ. 50 p.

APPENDIX A

ESTIMATION OF SELECTIVITY

Selectivity was estimated by a method that iteratively adjusts selectivity at each size to be consistent with assumed age structure in the population, and with observed age and size distributions in the catch.

The method proceeds according to the following steps:

1 Tabulate the raw catch by age and size categories.

2 Adjust the raw tabulated catch by dividing it by size specific selectivity coefficients. For the first iteration assume selectivity to be equal for all sizes.

3 For each age convert numbers at size to percentages (sum at every age equal to 100%).

4 Construct a population where numbers at age are governed by assumed mortality schedule, and number at each size within an age is governed by age-specific percentages from step 3. Sum up numbers across ages to obtain overall size distribution.

5 Divide the overall size distribution in the raw catch (step 1) by the overall size distribution from step 4, obtaining size-specific selectivity coefficients. Adjust the coefficients to a maximum of 1.0.

6 Go to step 2.

The procedure was tested with simulated data. It was found that true values of the selectivity coefficients were reached within a few iterations, and with large well behaved data sets the coefficients would stabilize. It was also found, however, that in small data sets, prone to noise in size frequency distribution, freak high values in the distribution would drive the coefficients in the other size categories towards zero, corrupting the process. It seems therefore, that the raw input data should be smoothed before the iteration. This approach was not tested.

The succes of the method depends on the assumed mortality schedule (or equivalent assumption about age structure), although it was found that even large errors in assumed mortality yield results that identify the overall shape of the selectivity curve.

APPENDIX B

SIMULATING THE EFFECTS OF SELECTIVITY

A population with the following features was assumed:

1 Age structure is governed by instantaneous mortality rate of 0.9 per year.

2 The fish grow according to the following von Bertalanffy equation:

$$\text{Mean total length at age (mm)} = 788.7 * (1 - e^{-0.359 * (age - 0.499)})$$

The fish deviate from this value according to normal distribution with standard deviation equal to 9% of the mean total length at age.

(These parameters were estimated from the data obtained in the Lake Ontario adult lake trout assessment program.)

3 The gear selectivity was derived from the selectivity profile from Superior strain 1985-87 pooled data:

- selectivity was assumed to be zero for fish smaller than 250 mm, and 1.0 for fish larger than 800 mm total length;
- The selectivity between 250 and 800 mm was approximated by the following polynomial:

$$\text{selectivity} = -8.933334e{-13}\ x^5 + 2.290082e{-9}\ x^4 - 2.261181e{-6}\ x^3 + 1.077316e{-3}\ x^2 - 0.247647 + 22.035699$$

For each age the expected number of caught fish was calculated by integrating the product of the gear selectivity function and of the normal distribution function describing variation in size around the mean length at age (area adjusted to proportion of fish at that age). Both are functions of length.

The mean length in the catch at each age was calculated as the expected value of the product of the two functions (Hillier and Lieberman, 1967, p.50).

REFERENCE:

HILLIER, F.S., and G.J. LIEBERMAN. 1967. Introduction to Operations Research. Holden-Day, Inc., San Francisco.

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WHITEFISH POPULATIONS IN EASTERN LAKE ONTARIO AND THE BAY OF QUINTE, 1988

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ABSTRACT

Index gillnets show dramatic increases of lake whitefish catches in the Kingston Basin of Lake Ontario. These large increases are consistent with large catches of YOY in trawls in the Bay of Quinte during 1986 and 1987, and in Lake Ontario during 1987. The population estimates of mature whitefish for the Bay of Quinte stock has doubled to 251456 whitefish. This is due to stronger year classes reaching the population.

RECOMMENDATIONS

1. Follow up the stock identification research with a complete analysis of the gillnets index series to separate the Lake and the Bay of Quinte stocks.

INTRODUCTION

Lake whitefish (*Coregonus clupeaformis*) comprised about 13% of the landed value of the commercial harvest in Lake Ontario in 1987 (Anonymous 1988). This value has increased from close to zero in the 1970s. Moreover, indications of population increases (Bowlby 1988a) suggest that the value will continue to rise. There are two morphologically different stocks of whitefish which contribute to this harvest (Bowlby 1988a). The Bay of Quinte stock spawns on shoals and in river mouths of the Bay. The Lake Ontario stock spawns for the most part along the south shore of Prince Edward County and perhaps along the south shore of Amherst Island. This report provides an update of the status of these two stocks.

PROCEDURES

During the fall 1987 and 1988 mark-recapture programs for walleye (*Stizostedion vitreum*) in the Bay of Quinte (Bowlby and Mathers 1988, 1989), lake whitefish from the Bay of Quinte stock were batch marked and recaptured. Marks were made by punching two individual rays on the dorsal fin. The punch combination was unique to the location and the marking session. Population estimates were made using the adjusted Petersen method (Ricker 1975). The sampling details were similar to other years (Bowlby 1988b). There was no mark-recapture program for Lake Ontario stock whitefish during 1988.

Commercial catch sampling was much reduced in 1988 compared to 1987. Only dockside samples were taken in 1988. Fork length was taken from up to 100 whitefish from a catch and 10% of those fish were also weighed and a scale was taken for aging (Bowlby 1988c).

Index gillnet and trawl data comes from several research and assessment programs. Young-of-the-year (YOY) data comes from Bay of Quinte and Lake Ontario Research trawl programs (Casselman et al. 1989) and gillnet data comes from the Research Lake Ontario program (Casselman et al. 1989) and the Assessment Lake Ontario Program (Mathers 1989).

POPULATION SIZE AND AGE STRUCTURE

Lake Ontario Stock

No population estimates are available for the Lake Ontario Stock. Index gillnets in the Kingston Basin catch both the Bay of Quinte and Lake stocks. Nevertheless, these gillnets show a dramatic increase in whitefish catches (Fig. 1). Currently, there is ongoing research by Dr. J. Casselman who is attempting to discriminate between the scales of these stocks. If this work is successful then we can use these gillnet catches to index the population of these two stocks. Note that the catch in 4.5 in. mesh has declined while the overall catch has increased in 1988. This decline is consistent with the decline in the older portion of the population of the Lake stock (Bowlby 1988b). The large increases in catch are consistent with large catches of YOY in trawls in both the Bay of Quinte and Lake Ontario (Fig. 2). The trawl data from Timber Island suggests an extremely strong 1987 year class for the Lake stock.

The age distribution of the commercial catch is encouraging because 2-, 3-, and 4-year-olds made about 30% of the catch in 1988 (Fig. 3), whereas these ages of fish contributed about 7% of the catch in 1987 (Bowlby 1988b). These year classes appear to be much larger than the previous two and should provide some stability to the portion of the population that is vulnerable to the fishery.

Bay of Quinte Stock

The population estimate for the Bay stock doubled to 251456 during 1986 to 1987 (Fig. 4). This is due to the recruitment of a large number of 3- and 4-year-olds to the population. We do not readily catch 3-year-olds in our trapnets because we sample the spawning run and most whitefish in this stock mature at 4 years of age. Accordingly, the large catch of 3-year-olds in our trapnets suggests that they are part of a stronger year class (Fig. 5). The trawl data from Conway suggests extremely strong 1986 and 1987 year classes (Fig. 2), and these fish may also account for the increased catches in index gillnets (Fig. 1).

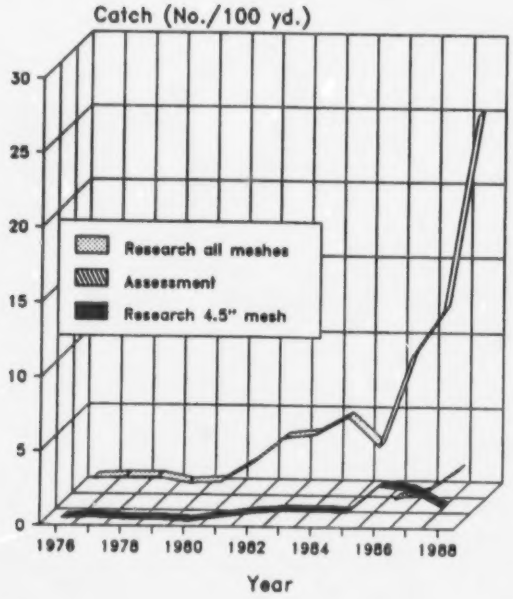

Figure 1. Catch per effort of whitefish in index gillnets in the Kingston Basin of Lake Ontario. Research all meshes data is from Casselman et al. (1989). Assessment data is from Mathers (1989).

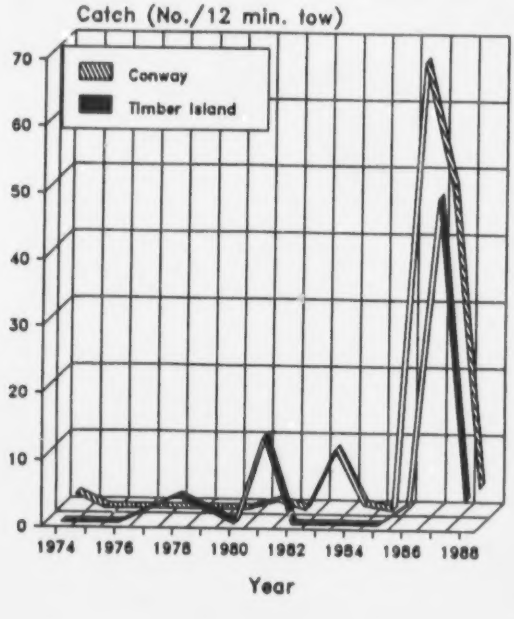

Figure 2. Catch per effort of YOY whitefish in Research trawls in Lake Ontario. Conway is in the Adolphus Reach of the Bay of Quinte. Timber Island is in the Kingston Basin of Lake Ontario.

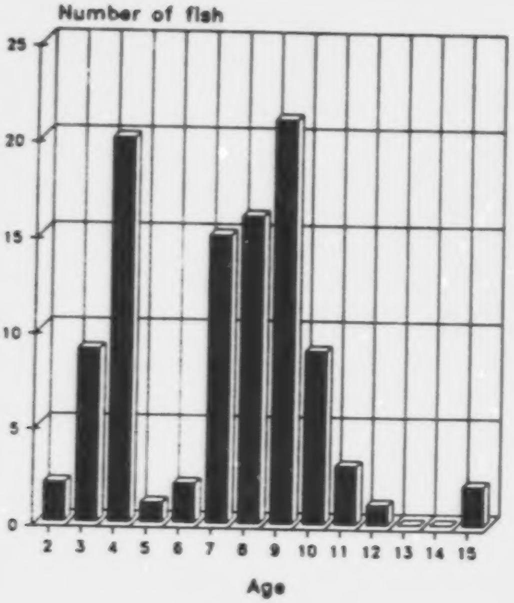

Figure 3. Age determination of whitefish from commercial gillnets in Lake Ontario during 1988.

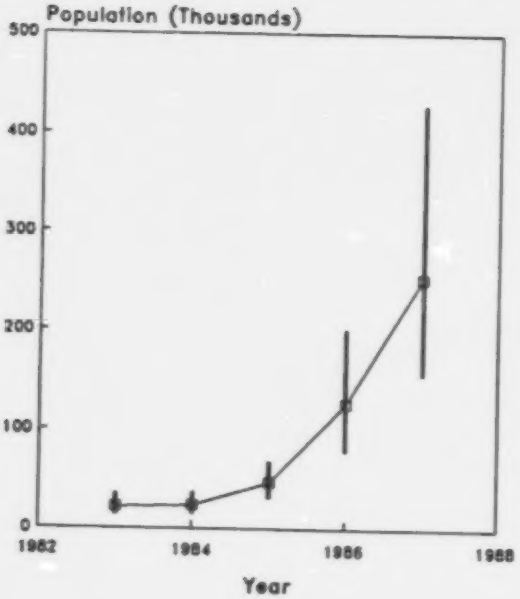

Figure 4. Population estimates of the Bay of Quinte stock of whitefish. Vertical bars represent 95% confidence limits.

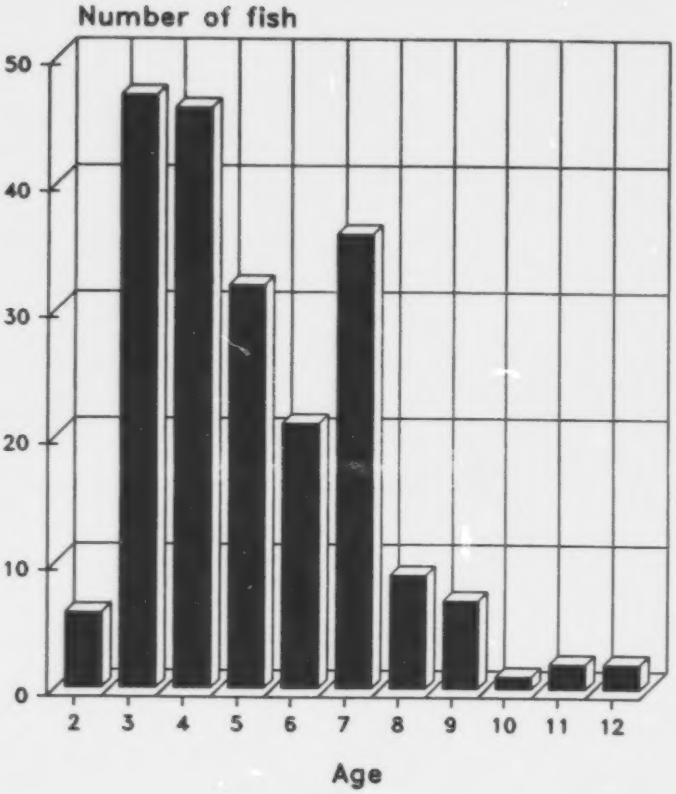

Figure 5. Age distribution of whitefish from mark-recapture trapnets in the Bay of Quinte during 1988.

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REFERENCES

ANONYMOUS. 1988. Summary of the 1987 commercial fish harvest in eastern Lake Ontario. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 13. LOA 88.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J. N. 1988a. Lake Ontario tagging program, 1987: I. Field and data entry protocol manual. LOA 87.6. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J. N. 1988b. Whitefish populations in eastern Lake Ontario and the Bay of Quinte, 1987. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 3. LOA 88.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J. N. 1988c. Whitefish commercial catch sampling, 1988, field and data protocol manual. LOA 88.14. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J. N., AND A. MATHERS. 1988. Walleye populations in eastern Lake Ontario and the Bay of Quinte, 1987. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 1. LOA 88.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

BOWLBY, J. N., AND A. MATHERS. 1989. Walleye populations in eastern Lake Ontario and the Bay of Quinte, 1988. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 8. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

CASSELMAN, J. M., D. A. HURLEY, M. S. RIDGWAY, AND R. S. STRUS. 1989. Research activities of the Lake Ontario Fisheries Unit. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 21. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

MATHERS, A. 1989. Index gillnetting project, 1988. *In* Lake Ontario Fisheries Unit 1988 Annual Report. Chapter 11. LOA 89.1. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Unit. Picton, Ontario.

Great Lakes Fishery Commission
Lake Ontario Committee
March 21-22, 1989
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RESEARCH ACTIVITIES OF THE LAKE ONTARIO FISHERIES UNIT

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INTRODUCTION

The following is a general report of the 1988-89 activities within the OMNR research section at the Lake Ontario Fisheries Unit. In 1988 Dr. John Casselman, with the Fisheries Research Section at Maple, officially transferred within the Research Section to the Lake Ontario Fisheries Unit as Senior Research Scientist supervising research on Lake Ontario. At Maple he supervised a fisheries research unit investigating Age-Growth and Environmental Studies aimed at refining, improving, and testing the validity of current methods of interpreting age and estimating growth of fish from their calcified structures. This provincial research responsibility will continue at the Lake Ontario Fisheries Unit facility.

Although several research projects are being conducted on this aspect of fisheries science, specific details will not be presented in this year's report. However, new methods are being developed, including marking procedures that make it possible to evaluate age interpretation techniques. Research is also being conducted on the effects of environmental factors on growth and productivity of fish, especially those associated with stress. This research, which is conducted on fish populations in the natural environment, provides known-age and partly-known-age fish, which provide not only precise data to evaluate growth and production but also structures and tissue that can be used to improve techniques for determining age and growth.

More specific details on these research projects are available in the Annual Report of Fisheries Research published by the OMNR Research Section. Indeed, the research component of the Lake Ontario Fisheries Unit currently prepares two types of annual reports each year--one written for the Lake Ontario Fisheries Unit's presentation to the Lake Ontario Committee GLFC, and one for publication by the Research Section, Fisheries Branch. In the past these two reports have had quite different formats and details. Preparation of these two different reports has been unnecessarily time-consuming. For this reason, in future these annual research reports will be identical and will be presented in the format used by Fisheries Research, which presents projects in the form of general **Objectives**, specific annual **Progress**, and general **Future Direction**, along with **Abstracts** of scientific papers that are either published, in press, or accepted for publication in the primary literature. For this year, the format of the current report, which follows, combines both types of presentations.

Historically, research efforts on Lake Ontario have been directed primarily at understanding the dynamics of the fish populations of the coldwater fish community of the outlet basin (Kingston Basin) of the east end of Lake Ontario and of the warmwater fish community of the Bay of Quinte. These studies have been built around many years of intensive and consistent sampling with standard experimental gear, and the extraction of detailed biological data on the fish collected. The sampling program involves essentially routine indexing procedures and has usually focused on large fish and older life stages. Generally the small fish and young life stages have not been adequately sampled in these programs. In addition to the population and community studies, research is conducted on sampling problems. In future research reports, this project will be presented separately as Fish Sampling Methodology.

Since the outlet basin and the Bay of Quinte sampling programs are essentially assessment procedures, they are currently under review in consultation with the assessment component of the Unit and Fisheries Management to officially transfer these types of index sampling programs to Assessment. At the same time, Research has initiated a systematic and objective review of fisheries research needs for Lake Ontario and its embayments. Research has requested that the assessment component of the Lake Ontario Fisheries Unit and Management assist in this review, and that they each provide a priorized list of their own important research needs. The culmination of this exercise will be a five-year research plan for the Research component of the Lake Ontario Fisheries Unit. This research plan will be finalized with input from the Great Lakes Coordinator and Research Supervisor of the Research Section, Fisheries Branch. It will provide specific details on projects that will not only meet the research needs for Lake Ontario and its embayments, but also address specific research problems that have provincial and general fisheries applicability.

PROJECT

Bay of Quinte Gillnet and Trawl Series

Investigator - D. A. Hurley

PURPOSE

The purpose of this program is to assess the fish populations of the Bay of Quinte using standard gear configurations at selected sites and times on a regular basis. The program began in 1958 and has expanded in scope since 1972. Initially only gillnets were used, but bottom trawl drags were introduced in 1972 and have continued since then.

This year replicate gillnet sets and trawl drags were made to determine the variance in the estimates.

METHODS

The gillnet consists of panels of graded mesh from 38 mm to 127 mm in 13-mm increments tied together as one net. The lengths of the panels are 22.8 m for smaller meshes and 45.7 m for larger meshes. The net is fished overnight from late afternoon to early the following morning. The catch-per-unit-of-effort (CUE) is calculated on the basis of the number of fish of each species prorated to 91.4 m of each mesh size and summed over all meshes.

In previous years one overnight set per month, May through August, at specific locations was used for the assessment. This year three nets were fished simultaneously at each site, once in late June and again in late August. From these data an estimate of variance could be derived. The coefficient of variation, the standard deviation divided by the mean, allows comparisons to be made independent of the size of the means.

Bottom trawl drags were made using a three-quarter size Western trawl 19 m long with 6-m wings and 13-mm mesh in the cod end. This gear was dragged a distance of 400 m at a speed of 1.1 m/sec. The CUE was the catch from one trawl drag. Previous to this year one drag was made each month from May through September at three or more locations in the bay. This year the protocol was altered to develop measures of variance. Six replicate trawls were made at each site in late June and again in late August. The earlier series would capture the early summer assemblage of fishes, while the August series would capture many young-of-year fish of several species.

RESULTS

Gillnets

Mean CUE's for the gillnet sets were calculated for the entire 1988 series, and the values are listed in Table 1 together with those from 1986 and 1987. Some noteworthy features are the relatively low CUE for alewife at Big Bay and the high value at Hay Bay. Gizzard shad have increased greatly in abundance in the last few years at all sites. White perch CUE has remained fairly constant over the last several years, while yellow perch CUE has fallen somewhat at Big Bay. Walleye abundance appears to be remaining at the level noted during the past few years. Freshwater drum were very abundant at Conway in 1988.

The data from replicate gillnet sets in each area and time period were log transformed and the coefficients of variation were calculated on the transformed data. These coefficients permit an evaluation of the amount of variance present in the data for each species encountered.

TABLE 1. Mean catch per standard gillnet lift in the Bay of Quinte.

	Big Bay			Hay Bay			Conway		
Species	1986	1987	1988	1986	1987	1988	1986	1987	1988
Longnose gar	0	41.5	14.0	0	0	0	4.5	0	0
Alewife	422.5	178.0	43.3	249.0	191.5	929.3	808.0	741.0	462.4
Gizzard shad	10.5	22.5	143.7	2.5	2.5	218.0	0.5	0	16.0
Bullhead	43.0	62.0	40.3	45.5	16.5	18.0	1.0	0	0
Channel catfish	14.5	31.0	29.7	1.5	0	4.5	0	0	0.8
White sucker	29.9	26.5	25.3	7.0	23.5	10.7	50.5	127.0	78.8
Northern pike	5.0	5.0	3.7	1.0	5.5	1.3	0.5	0	0.4
Pumpkinseed	0.5	0.5	0.3	1.0	0.5	2.0	1.5	0	2.4
Smallmouth bass	6.0	2.0	8.7	7.5	4.0	0.7	4.0	1.0	13.2
White perch	482.0	713.0	696.7	99.5	83.5	93.0	59.0	70.5	24.0
Yellow perch	163.5	123.0	72.0	478.0	300.5	514.0	1189.0	949.0	998.8
Walleye	35.0	110.0	82.3	49.5	13.5	25.7	78.5	23.5	26.8
Freshwater drum	32.5	35.0	41.3	23.5	7.0	16.7	1.0	0	40.8

Table 2 lists the coefficients for those samples in which the means were significantly greater than zero. In most cases the species that were present in relatively large numbers were those with the smallest coefficients. For example, white perch, yellow perch, walleye, ictalurids, and drum were usually consistently found at a site at any one time. In contrast, alewife numbers tended to vary to a large degree from one catch to the next. Those species that were infrequently encountered also had large coefficients.

These results indicate that the gillnets do sample relatively consistently and that the abundance measures gathered from them probably reflect the actual situation. One criticism that could be made is that more replicates should be considered. Hopefully, next year this series can be extended to six instead of three replicates.

Trawls

The CUE's derived from the trawl series are given in Table 3, together with results from 1986 and 1987. Alewife abundance remains low in the upper bay at Big Bay as it has for the past several years but is much higher at both Hay Bay and Conway in the lower Bay of Quinte. It is postulated that the low abundance in the upper bay is the result of heavy predation from walleye in that area. Gizzard shad have increased in abundance at both Big Bay and Hay Bay. White perch are at the same level that they have been for the past several years, and there is little evidence that their numbers are returning to the high values (170 to 1060) seen in the mid 1970's. Both yellow perch and walleye numbers are somewhat lower than in the previous years, but the significance of this is difficult to judge.

The six replicates permitted measures of variance to be calculated. Data were log transformed and coefficients of variation calculated on these values. The values listed in Table 4 show that there was considerable variation within the series, with the greatest variance present where catches were low (between 1 and 100). The series may be increased to ten next year in an effort to reduce the variance.

Young-of-Year Abundance

i) Walleye

The bottom trawl catches significant YOY walleye in late August when they are vulnerable to the gear. Data in Table 5 give an index of abundance in the three sampling areas since 1972. The large 1978 year-class became evident in the fall of 1978, especially in the Big Bay area. Since 1981 there have been consistent catches of YOY each year, with high numbers recorded in 1982 and 1986. This pattern may reflect the first spawning of large year-classes in 1978 and 1982. If this same pattern persists, then large numbers of YOY should be found in 1990.

TABLE 2. Coefficient of variation (%) calculated on log transformed gillnet CUE values for 1988. In each case N=3.

	Big Bay		Hay Bay	
Species	June	August	June	August
Longnose gar	38.5			
Alewife			18.4	25.2
Gizzard shad		8.3		14.2
Lake trout				
Lake whitefish				
White sucker	21.6	5.7	12.5	32.9
Brown bullhead	8.8	16.7		6.2
Channel catfish	2.6	12.1		
White perch	1.5	5.2		1.4
Rock bass				
Smallmouth bass	29.7	23.3		
Yellow perch	14.1	6.5	5.1	4.9
Walleye	8.2	2.2		7.1
Drum	17.3	19.2		10.7

TABLE 3. Mean catch per 0.25 mile trawl in the Bay of Quinte.

	Big Bay			Hay Bay			Conway		
Species	1986	1987	1988	1986	1987	1988	1986	1987	1988
Alewife	18.6	55.6	11.5	289.6	298.8	212.8	320.2	438.0	2494.3
Gizzard shad	1.0	114.8	464.6	0.6	25.4	127.8	0.2	0	0
Smelt	0	0	0	197.0	3.8	57.5	497.8	296.6	697.9
Trout-perch	18.0	7.0	2.8	39.6	129.8	21.3	98.0	198.8	100.9
Brown bullhead	9.4	4.0	0.8	2.0	5.0	4.5	0	0	0
White perch	44.2	186.6	42.6	51.6	23.8	24.8	10.6	6.6	1.8
Yellow perch	9.8	5.0	0.9	13.6	53.4	12.2	32.0	44.4	25.3
Walleye	17.0	6.8	2.9	9.8	14.0	11.5	12.4	12.8	5.2

TABLE 4. Coefficient of variation (%) calculated on log transformed trawl catches.

	Big Bay		Hay Bay		Conway	
Species	June	August	June	August	June	August
Alewife		69.9	9.0	104.2	10.5	
Gizzard shad		3.7		21.3		
Lake whitefish					15.4	
R. smelt			8.0		14.3	
W. sucker				36.5		
Spottail shiner				17.5		
B. bullhead				30.4		
Trout-perch		86.3		15.9	12.2	15.7
White perch		31.4		8.8		
Yellow perch				31.7	14.0	
Walleye			34.2	12.3	54.1	

TABLE 5. Mean number of age 0 walleye per hectare from bottom trawl drags, May-October. Note the 1988 series is composed of six replicate trawls in late June and again in late August.

Year	Big Bay	Hay Bay	Conway
1972	0.0	0.0	0.0
1973	0.0	0.0	0.0
1974	0.0	0.0	0.0
1975	0.0	0.0	0.0
1976	0.0	0.0	0.0
1977	0.0	0.0	0.0
1978	29.4	12.2	0.0
1979	0.0	3.4	0.0
1980	0.0	0.0	0.0
1981	5.5	1.5	0.8
1982	32.7	0.0	0.0
1983	2.5	2.5	4.4
1984	1.6	5.0	0.0
1985	17.8	18.8	0.0
1986	48.5	21.2	22.8
1987	5.7	13.9	15.5
1988	6.5	6.1	11.2

ii) White Perch

Estimates of both total white perch biomass and YOY biomass were calculated from the trawl catches (Table 6). The dramatic drop in biomass after 1977 is evident, together with the resurgence noted in 1981, 1986 and 1987. The increased proportion of YOY in relation to total biomass is evident after 1978, with the exception of 1985 and 1986 when YOY biomass was low. It appears that white perch are producing large numbers of YOY but these are not surviving to older age groups. Predation would appear to be the most likely cause of the drop in numbers and is probably also the mechanism that is currently controlling white perch numbers.

TABLE 6. White perch biomass, $kg.ha^{-1}$, from bottom trawl drags in the upper Bay of Quinte in August and September.

Year	Total Biomass	YOY Biomass	Proportion Of YOY (%)
1972	66.0	1.2	1.8
1973	69.0	1.3	1.8
1974	45.9	0.2	0.5

Table 6. Concluded

1975	143.2	13.4	9.4
1976	59.6	0.2	0.4
1977	117.8	3.2	2.7
1978	0.6	<0.1	0.7
1979	4.1	1.7	41.5
1980	2.6	0.9	33.2
1981	20.5	5.9	28.6
1982	2.1	0.9	43.7
1983	7.3	2.2	30.1
1984	1.7	0.4	24.4
1985	13.2	0.2	1.3
1986	35.4	0.7	1.9
1987	20.3	7.3	35.8
1988	3.3	1.8	53.1

PROJECT

Experimental Studies of Gillnet Catches

Investigators - C. K. Minns (DFO) and D. A. Hurley

Tests of certain assumptions of the effect of net length and the number of hours that nets are set were made in 1983 and 1984 at two sites in the Bay of Quinte. The results of this study appeared in the North American Journal of Fisheries Management 8:216-223 in 1988, and the abstract of that article follows.

ABSTRACT

Effects of net length and set time on fish catches in gill nets. C. K. Minns and D. A. Hurley.

The effects of varying net length and set time on fish catches in gill nets were studied at two sites in the Bay of Quinte, Lake Ontario. A latin square design was used (four locations per site over four nights); either net length was varied, from 25 to 200 yd over 12 h, or set time was varied, from 1.5 to 12 h with 50 yd of net. Treatment, location, and date effects on catches from each site were analyzed by a multiple regression model. Net length effects on catch per unit of effort (CPUE) were negligible for total and some fish species catches; CPUE for walleyes (*Stizostedion vitreum*) decreased with net length. Set-time effects on total CPUE were significant; the CPUE of white perch (*Morone americana*) increased with set time, but CPUEs for yellow perch (*Perca flavescens*), alewives (*Alosa pseudoharengus*), and walleyes decreased. The results were attributable to specific differences in activity patterns and net-saturation effects. We concluded that use of gill-net catches as indices of fish abundance must be validated species by species.

PROJECT

Trophic Studies

Investigators - D. A. Hurley and K. H. Nicholls (OME)

A paper on the effects of factors other than phosphorus in phytoplankton production in the Bay of Quinte was accepted by the Canadian Journal of Fisheries and Aquatic Sciences to be published in 1989. The abstract for that paper follows.

ABSTRACT

Recent changes in the phytoplankton of the Bay of Quinte: the relative importance of fish, nutrients, and other factors. K. H. Nicholls and D. A. Hurley.

A 50% reduction in phosphorus loading to the upper Bay of Quinte (Lake Ontario) from municipal sources in 1977 was followed by a major decline in phytoplankton biomass in 1978. However, by 1984-85 biomasses again approached those of the pre-phosphorus control period, despite continued low phosphorus loadings. No major shifts in phytoplankton composition occurred; domination by the diatoms *Melosira* and *Stephanodiscus* spp. and the blue-green algae *Anabaena* and *Aphanizomenon* spp. has continued.

Highly significant positive correlation coefficients ($r = 0.92 - 0.98$) were found for phytoplankton - fish relationships during both the pre- and post phosphorus removal periods which coincided with pre- and post die-off periods of white perch (*Morone americana*) and alewife (*Alosa pseudoharengus*). For the entire 16-year period of data collection, a multiple regression model fitting upper bay phytoplankton biomass (with an adjusted R^2 of 0.83) was developed with five input variables. White perch biomass alone explained more than 50% of the variance in the model. It is hypothesized that trophic interactions among other biotic components in the Bay of Quinte may be very important in controlling phytoplankton biomass.

PROJECT

Bay of Quinte White Perch Studies

Investigator - D. A. Hurley, M. S. Ridgway, and R. H. Strus

Studies of this species have continued over the past year in two general areas: factors affecting year-class strength and diet.

Year-class strength in white perch is strongly affected by water temperatures and levels and overwinter temperatures in the period immediately preceding spawning. The regression equation that best describes these effects on year-class strength is:

$$YC = 22532 - 1.147B + 1.734K - 331.497L - 1.018M + 3.456J$$

Adjusted $R^2 = 72.0\%$

YC = year-class strength as cumulative CUE by age groups from gillnet data,
B = annual thermal sum of daily water temperatures from the Belleville Filtration Plant for the period Nov. 1 through April 30,
K = same as above for Kingston Filtration plant,
L = mean annual May through August lake level at Oswego, N.Y., in meters above sea level,
M = sum of daily water temperature from the Belleville Filtration plant for the month of May in the year of spawning,
J = same as above for the month of July.

The presence of adult white perch in both the upper bay of Quinte near Belleville and in the lower bay in winter (November) was confirmed by setting gillnets in these locations this year. It is presumed that overwinter temperatures affect in some way either adult survival or the development of viable gametes for that spring. The effect of water level is not understood. It was shown that larger year-classes were associated with low water levels. It is possible that low water levels were related to reduced habitat for northern pike, and since northern pike are major predators on white perch, the predation pressure on white perch may have been reduced. Water temperatures in May and July probably influence spawning events and early life history stages.

The purpose of the diet studies was to complete the series that spanned the 1970's and early 1980's and to determine if qualitative changes had occurred that may be related to increased zooplankton production and, in turn, affect phytoplankton biomass. The data have yet to be analyzed, but initial findings show that large daphnids such as *Daphnia galeata mendotae* and *Daphnia pulex* and other large cladocerans such as *Eurycercus lamellatus* are important food items for white perch. These large forms are effective phytoplankton grazers, so reductions in their numbers through predation would favor increased phytoplankton biomass. The relationship between trophic levels and the biomass elaborated at each level is an active area of current research.

PROJECT

Gillnet Selectivity for White Perch

Investigators - M. S. Ridgway and D. A. Hurley

OBJECTIVES

To assess gillnet selectivity for white perch in the Bay of Quinte. This species is of growing importance in the Great Lakes, and little information is currently available on its population ecology. As a first step in summarizing the Glenora data set on white perch, we will determine the selectivity of different mesh sizes towards white perch.

BACKGROUND

The issue of selectivity of various gillnet mesh sizes for fish of different size can be resolved by either ignoring the problem or attempting to assess the selectivity of different meshes. Traditional assumptions in work on gillnet selectivity include relatively normal 'bell-shaped' curves and constant efficiency across all mesh sizes when catching fish of different size. In contrast, direct measures of gillnet selectivity on populations of a known size distribution reveal unequal efficiencies of different meshes and a tendency for the peaks of the selectivity curves to increase in magnitude from small to large meshes. Also, most of the gillnet selectivity literature addresses only the probability of retention after a fish has encountered the net (e.g., girth/perimeter ratio). A better model for representing the predatory behaviour of gillnets would also include the probability of encountering prey of different sizes. This predation model would include a prey encounter component (such as swimming speed of fish of different size) and a prey handling component (such as girth/perimeter ratio). In the one case where this approach was applied (Rudstam et al. 1984), the resulting selectivity curves followed the pattern observed by direct methods; that is, efficiency increased with mesh size and the peaks of the curves increased with mesh size as well. This procedure is very promising as an indirect method for determining gillnet selectivity.

PROGRESS

We intend to apply this indirect method to determine gillnet selectivity curves for white perch in the Bay of Quinte. We have calculated master selectivity curves based on the girth/perimeter method (McCombie and Fry 1960; Hamley 1975). Each curve represents one of three periods in the history of white perch in the Bay of Quinte; 1959-64, 1969-74, and 1979-84. These periods represent periods of medium, high, and low density respectively. A preliminary summary of the data from these periods confirmed our initial suspicion that density (and its correlate, average body size) strongly affected the distribution of catch among different meshes. For example, during the high density period of 1969-74 the catch of fish in the smallest mesh size was clearly higher than during the low density period of 1979-84 in which catches were higher in larger meshes.

We have not assumed normality in the selectivity curves; instead we calculated the left and right sides of the curve using modified logistic equations provided by Thornten and Lessem (1978). This requires a minimal set of data including the left and right ends of the 'bell' curve and an estimate of the peak. The peak can be estimated using a fourth order polynomial (from the 'fit polynomial function' of the RS1 program).

What remains to be done is to determine a relationship between swimming speed and fish size that will serve to adjust the master curves according to encounter probability. There is little data in the literature on this matter (Rudstam et al. 1984), but the limited information available suggests that a power function relating size and swimming speed will be found. Estimating swimming speeds is a project that can be undertaken when the research staff moves into the renovated building.

REFERENCES

HAMLEY, J. M. 1975. Review of gillnet selectivity. J. Fish. Res. Board Can. 32:1943-1969.

McCOMBIE, A. M., AND F. E. J. FRY. 1960. Selectivity of gill nets for lake whitefish, (*Coregonus clupeaformis*). Trans. Am. Fish. Soc. 89: 176-184.

RUDSTAM, L. G., J. J. MAGNUSON, AND W. TONN. 1984. Size selectivity of passive fishing gear: a correction for encounter probability applied to gill nets. Can. J. Fish. Aquat. Sci. 41:1252-1255.

THORNTEN, K. W., AND A. S. LESSEM. 1978. A temperature algorithm for modifying biological rates. Trans. Am. Fish. Soc. 107:284-287.

PROJECT

Fish Community Studies of the Outlet Basin of Lake Ontario

Investigators: J. M. Casselman, W. J. Christie, and K. A. Scott

OBJECTIVES

Since 1961, fish sampling has been conducted annually at the community level in the outlet basin in the east end of Lake Ontario. Over this 27-year period, six stations have been sampled consistently once each month during the summer (May-August) with multifilament experimental gillnets, ranging in mesh size from 1.5 to 6 inches, and since 1972 with a 3/4 "Yankee Standard" No. 35 bottom trawl. Although these stations were originally established to assess change in the whitefish population, they have become standard "lake" index stations for Fisheries Research.

More recently, these sampling data have been used to study the response of the fish community to sea lamprey control and the reintroduction of the formerly abundant piscivorous lake trout. They have also provided the opportunity to assess the effects of alterations in water quality on the fish community of the Bay of Quinte and the adjacent waters of the outlet basin of Lake Ontario, with special emphasis placed on such species as walleye, lake whitefish, lake herring, smelt, and alewife.

PROGRESS

Recently, a general analysis of this data set was conducted by Christie et al. for the ASPY Symposium in 1985. However, in 1988, Casselman and the other investigators conducted additional analyses, incorporating more recent data. Their conclusions are summarized in the following abstract of a paper presented to IAGLAR in May 1988.

ABSTRACT

The dynamics of the fish community of the outlet basin of Lake Ontario--recent trends. J. M. Casselman, W. J. Christie, and K. A. Scott.

Over the past 12 years, more than 2.5 million yearling lake trout have been stocked in the Canadian waters of the outlet basin of Lake Ontario as part of the lake trout rehabilitation program. This steady increase in stocked fish has resulted in a linear increase in the catch of lake trout in experimental gillnets. Starting in 1983, there has been a significant increase in the numbers of mature lake trout congregating on historic spawning sites (e.g., Yorkshire Bar--in 1984 there was a four-fold increase over 1983, and in 1987 there was a three-fold increase over 1984). This substantial increase in mature spawning trout, which commenced in 1983, coincided with midsummer catches in experimental gillnets in the outlet basin which, for the first time, reached levels usually observed in naturally-reproducing and self-sustaining lake trout populations in inland lakes (e.g., 3 to 12 lake trout per 100 m^2 of experimental gillnet).

This increased biomass of piscivorous lake trout has substantially altered prey populations and is effecting community changes. The whitefish population has increased concurrently with the lake trout increases, but lagging 3 to 4 years. There are recent indications that after many years the lake herring population may be recovering. The numbers of yellow perch in the deeper waters of the outlet basin have decreased precipitously in recent years. There has been a substantial decrease in the numbers of large alewife and smelt, and slimy sculpins have decreased in both size and number. Over the past 11 years, there has been a steady decrease of 15 to 20% in the length of sculpins and smelt taken in bottom trawls and lake trout stomachs. Over the past 30 years, the prey utilized by lake trout has shown a prominent shift from primarily slimy sculpin to equal representation of smelt, sculpin, and alewife, and recently with a five- to seven-fold decrease in smelt and sculpin to an increasing dependence on alewife.

Over the last 13 years, there has been a gradual decrease in body condition of lake trout. However, in the past two years there has been a prominent decrease in the condition of all size classes of lake over 200 mm fork length. This recent decrease in midsummer condition, which coincides with a decreased utilization of smelt and sculpin, indicates that decreases in growth rate, size at first maturity, and fecundity may now be occurring.

Sampling variance of both predator and prey must be measured and understood to evaluate the true significance of these recent, relatively short-term community trends. Nevertheless, the gradual decrease in the size and numbers of sculpins, the recent reduction in numbers of large smelt and alewife, and the increasing dependence of lake trout on the more pelagic alewife emphasize the extreme predation pressure being placed on the prey species by the increasing biomass of lake trout and the potentially precarious state of the alewife stock.

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As has been traditional for this report, catch data for the bottom-set gillnet and trawl series are presented in tabular form (Tables 7 and 8). The following general observations are made, cautioning that each is presented independent of any measure of sampling variability. It should also be noted that the summer of 1988 was abnormally warm, and that in August the thermocline reached the bottom over most of the outlet basin. This no doubt greatly affected the distribution and abundance of fish in the outlet basin. There is some evidence that in August many lake trout moved out of the outlet basin and into the main basin of Lake Ontario. If this warming was due to general climate change, then this long-term eastern basin data set may prove invaluable in the future in examining fish distribution and population change in relation to general climate warming, since the eastern basin has a uniform depth that is slightly greater than the usual maximum depth of the thermocline. The relationship between temperature in the outlet basin and CUE and its variability is being examined.

In 1988, considerably fewer large, and more small, alewife, smelt, and sculpins were caught than in previous years. This is no doubt related to increased predation pressure, since it has been shown that lake trout in the outlet basin are selectively preying upon the large individuals of the prey species. The lake herring catches and the lake trout caught in July in 4-inch mesh remained relatively high and unchanged from previous years. The lake whitefish and trout-perch catches were very much higher than in previous years. However, a detailed study of temperature differences in 1988 is required before it can be determined if this is a thermal anomaly or a real change in abundance.

TABLE 7. Relative abundance of fishes in the outlet basin of Lake Ontario, 1961-88, as indicated by numbers caught in experimental gillnets set 26-38 m deep. Six stations were sampled once during June, July, and August, and the results were averaged. The experimental gillnets were of white multifilament 6 ft (1.83 m) deep and were composed of two 25-yd (22.86-m) panels of 1.5- and 2-inch mesh and two sets of eight 50-yd (45.72-m) panels, ranging from 2.5- to 6-inch mesh stretch in 0.5-inch intervals. Lake trout catches were of fish taken in July in 4.5-inch mesh.

Year	Alewife	Smelt	Yellow perch	Lake herring	Lake whitefish	Lake trout
1961	147	147	7		3.1	0.03
1962	141	83	22		2.4	0.07
1963	228	141	5	0.3	2.0	0.09
1964	20	161		0.3	0.3	0.42
1966	1306	253	28	0.8	0.8	0.00
1967	245	132	12	0.2	0.7	0.00
1968	110	222	18	0.5	1.5	0.00
1969	599	217	26	0.8	0.8	0.00
1970	1089	232	38	1.1	0.9	0.00
1971	349	208	20	0.8	1.2	0.00
1972	51	580	14	0.9	0.6	0.00
1973	125	197	23	0.7	0.5	0.00
1974	2121	312	56	1.1	0.3	0.00
1975	587	379	21	1.1	0.8	0.88
1976	757	263	8	0.9	0.6	0.25
1977	46	212	23	0.7	0.6	0.92
1978	84	335	59	0.8	0.5	2.75
1979	146	362	16	0.8	0.4	3.08
1980	189	343	29	0.4	0.5	6.50
1981	585	307	71	1.3	1.8	3.00
1982	872	231	35	0.9	3.5	6.00
1983[a]	359	200	16	0.5	3.8	9.92
1984[b]	83	158	1	2.6	5.0	10.33
1985	976	151	10	1.0	3.0	17.50
1986	741	116	4	1.4	9.1	11.67
1987	987	203	1	2.0	12.2	13.50
1988	361	63	28	1.7	25.3	12.66
Average	493	217	23	0.9	3.0	3.68

[a] July and August only.

[b] August only.

TABLE 8. Relative abundance of fishes in the outlet basin of Lake Ontario, 1972-1988, as indicated by numbers caught in a 1-mile (1609.34-m) tow of a three-quarter "Yankee Standard" No. 35 bottom trawl drug at a depth of 26-38 m. Six stations were sampled once during June, July, and August, and the results were averaged. The trawl had a 0.5-inch cod end; however, from 1977 to 1988, with the exception of 1983, a 0.25-inch mesh liner was used.

Year	Alewife	Smelt	Sculpin	Trout-perch	Johnny darter
1972[a]	214.0	1200.6	225.4	13.4	0.3
1973	308.0	2013.7	460.3	25.7	1.0
1974	3519.8	1480.7	122.4	44.8	0.1
1975	730.9	1777.4	137.0	27.1	0.7
1976	1255.3	1425.2	119.3	29.8	0.7
1977	74.3	1220.8	106.8	19.1	1.6
1978	691.2	2117.5	113.0	233.6	2.1
1979	143.6	2420.8	138.9	196.7	2.0
1980	488.8	3004.7	164.7	120.6	1.4
1981	1306.7	3539.7	149.8	86.4	3.0
1982	1052.6	3088.7	62.3	17.3	2.8
1983[b]	408.0	4102.8	95.3	346.3	0.7
1984[b]	321.5	2366.8	51.8	105.3	0.8
1985	2470.9	5995.9	112.3	87.7	4.0
1986	209.0	2934.7	131.4	31.7	1.1
1987	188.4	2761.1	98.4	91.2	2.0
1988	2141.6	3474.4	64.6	248.6	4.8
Average	913.3	2642.7	138.4	101.5	1.7

[a] July only.

[b] July and August only.

A study of the sampling variability in the outlet basin data set has begun, and during the 1988 sampling period green monofilament experimental gillnets were used at each station in conjunction with the routine sets of standard white multifilament experimental gillnets (specially hung to gill whitefish). Traditionally, the multifilament gillnets have been set as two nets, one containing finer mesh (1.5- and 2-inch). In 1988, the catches of these two nets were treated separately. This was done to obtain a better measure of the observational variability associated with these sampling stations. The monofilament gillnet contains some finer mesh (0.5, 0.75, and 1 inch), but as is traditional, all catches were kept distinct by mesh size. The multifilament nets (1421.4 m^2) exerted 3.48 times as much effort as the monofilament nets (408.8 m^2). In 1988, replicate trawling was conducted at each station, using four comparably similar drags.

Sampling variability is being measured, using the log-transformed catch data to calculate the coefficient of variation. Since netting at each station has not been replicated to test within station variability, the analyses that are currently being conducted involve examining the variance among the stations in the outlet basin. This will provide some measure of the variability within the basin (basin observational variability), which is a reflection of the homogeneity of the fish populations and community of the outlet basin. From the experimental gillnet catches in July and August over the past 27 years, it is apparent that of all species and regardless of depth, smelt were taken with the lowest variance (CV = 19.2%). Trawl samples have a lower average annual coefficient of variation (CV = 17.5%), indicating that smelt are more homogeneously distributed on the bottom of the outlet basin, and that trawls have a lower sampling variability because they took smaller fish than the gillnets. Younger life stages usually have higher sampling variability. Alewife (63.1%) and lake trout (80.9%) had the next lowest average annual sampling variability. As expected, the variability of most species varied over the years in relation to sample size. As exemplified by lake trout, sampling variability was high when the catches were low in the 1960's (200%), and are currently low (20%) when the catches are high.

There are intrinsic differences in the way monofilament and multifilament gillnets sample fish populations. Generally multifilament experimental gillnets have a much higher sampling variability than do monofilament gillnets. When the effort used to sample the fish community of the outlet basin in 1988 was standardized, the multifilament nets had, on the average, 3.4 times the variability of that of the monofilament nets; it would require 12 times the effort to obtain the same low level of sampling variability. The multifilament nets were most consistent in sampling smelt, although the variance was still greater (1.9) than with monofilament nets. There was also one very notable exception, which involved the multifilament series set in deep water (30-40 m). They took lake whitefish much more consistently (variability was 4.1 times lower) that did the monofilament nets. It is not surprising that these nets took lake whitefish in deep water more consistently than the monofilament nets and more consistently than other species, because these multifilament gill nets are identical (material and hanging ratios) to the nets referred to as "whitefish nets" that were developed and used for many years by fishermen who commercially gillnetted whitefish in deep water in the eastern basin of Lake Ontario.

Sampling variability is also being examined within stations and with depth. Catch statistics are being used from the green monofilament experimental gillnet that is being used in the juvenile lake trout research study being conducted in the St. Lawrence trench southeast of Yorkshire Island. The within-station sampling variability (replicated 3-5 times), which is actually the observational variability associated with this gear, varies with species and depth, but with some species can be quite low (e.g., lake trout--experimental gillnets 0.5- to 5-inch mesh and 1.5- to 5-inch mesh: 31.3 m-depth, CV = 23.3 and 1.5; 47.0-m depth, CV = 21.7 and 8.0; 54.0-m depth, CV = 21.4 and 5.1, respectively). Although these data do not provide the best comparison of the variability within and among stations in the outlet basin, depending upon depth (20-30 m and 30-40 m), the among-station variability may be four to eight times greater than the within-station variability.

Until funds are available to adequately replicate sampling effort at these stations in the outlet basin, it is proposed that these nets be subsampled in 50-ft (15.24-m) intervals to obtain an approximate measure of their observational variability.

PROJECT

Research on Lake Trout Rehabilitation

Investigator - J. M. Casselman

Over the past 12 years, more than 2.5 million lake trout have been stocked in the Canadian waters of the outlet basin of Lake Ontario. This intensive stocking program has been conducted in order to rehabilitate lake trout stocks. There is evidence that since 1984 substantial numbers of hatchery lake trout are frequenting native historic spawning areas in the east end of Lake Ontario at spawning time. The females develop viable eggs, which appear to be deposited, because spent females are taken after spawning and some naturally-deposited eggs have been collected by researchers studying lake trout spawning at Stoney Island. If eggs are stripped from these females and artificially fertilized, they have a high survival rate and develop normally if reared under hatchery conditions. There is no evidence yet from routine sampling that appreciable numbers of mature fry or young lake trout are being produced. Although adequate spawning may not have gone on long enough to produce perceivable natural recruitment, there is some evidence that either spawning and egg deposition or the survival and development of eggs and fry are inadequate or low. It could also be that indigenous juvenile lake trout are indeed present but are not being sampled adequately. For this reason, two research studies are being conducted to examine these aspects of the lake trout rehabilitation problem. One involves studies of lake trout spawning in autumn; the other concerns an evaluation of the environmental requirements and habitat of fry and juvenile lake trout conducted in summer, and involves sampling potential nursery habitat in the vicinity of historic spawning areas.

A. Project - Studies of lake trout spawning

OBJECTIVES

This study was commenced in 1987 to examine lake trout congregation at spawning time and spawning in the outlet basin of Lake Ontario. Yorkshire Bar was chosen as a study area because it was a well-documented, traditional spawning ground of native lake trout, and from 1975 to 1984 Fisheries Research had sampled lake trout on the bar at spawning time with experimental gillnets. These data sets provided an opportunity to evaluate the re-establishment of a spawning stock in the outlet basin of Lake Ontario and assess the utilization of an historic spawning site. Very importantly, a good sheltered harbour is nearby on Main Duck Island. The specific objectives of the study are: (1) to study spawning congregations that are developing around traditional spawning grounds, specifically Yorkshire Bar; (2) to compare the density and behaviour of these fish with other indigenous stocks and with other current and historical information from Lake Ontario; (3) to determine the spawning behaviour of these lake trout and establish if they are successfully depositing viable, fertilized eggs; and (4) to measure the density and location of these eggs in relation to the available substrate.

PROGRESS

During July 1988, the Canadian Hydrographic Survey of Fisheries and Oceans, Bayfield Institute, did a detailed hydrographic survey of Yorkshire Bar, which provided a computer-based contour map constructed with 5-m sweeps and a depth precision of 10 cm. With this chart it is possible to determine the precise location of the congregations of lake trout that were discovered at spawning time in 1987. This pin-pointed the part of the bar that was frequented actively by mature fish during the previous spawning season. Range poles were placed on Yorkshire Island so that it was possible to visually align and locate the steep slope on the east side of the bar adjacent to the crest between the 3- to 6-m contours.

An underwater survey was conducted in midsummer by E. Marsden and P. Savoie to assess and locate suitable lake trout spawning substrate. Excellent rubble was observed in a narrow strip on the steep east slope of the bar over a depth range of 3 to 6 m. This band of substrate is the exact location where the greatest concentrations of lake trout were live-netted at spawning time during the previous autumn. In this band the suitable substrate is several layers deep, and the interstitial spaces are extremely clean. At the time of the survey there was, however, a dense mat of *Cladophora* in the shallower areas, which in 1987 had died down and was mostly eroded away by spawning time. The divers concluded that this area provided excellent substrate for lake trout spawning.

In October and November 1988, as was done in 1987, monofilament gillnets were set after dusk for a short time (1-2 hr) to live-capture mature lake trout. A sampling design similar to that used in 1987 was attempted. It was planned to sample the lake trout congregations on the shoal more frequently in 1988. However, gales, severe winds, and changeable weather fronts made logistics extremely difficult and sampling on the bar a greater problem than in 1987. Nevertheless, Yorkshire Bar was netted on four separate nights (Table 9) encompassing peak spawning, which occurred at approximately the same time and temperature as in 1987. However, there is some indication that ripe and running females were present on the bar earlier in 1988.

Table 9. Yorkshire Island Bar--lake trout spawning study 1988. Catch per unit effort expressed as numbers caught per 100 m^2 of gillnets. Gillnet sets were composed of two panels each 50 ft (15.24 m) x 8 ft (2.44 m) made of green monofilament, one 2.5- (63.5-mm) and one 3.0-inch (76.2-mm) mesh. Nets were set at dusk for 1 to 2 hours duration (with catches adjusted to 2 to 3 hours duration to provide comparable results to 1987.

Date	Water temperature at 5 m	No. of net sets	CUE at depth (m)			No. of lake trout		Percent males		Percent females		
			3	4	6	caught	tagged	total	ripe and running (rank >5)	total	ripe and running	spent
Oct. 20	13.2	2	64.8	43.1		40	34	93.8	26.8	6.2	25.0	0.0
Oct. 31	10.2	2		24.2	61.9	32	29	67.2	40.7	32.9	10.0	0.0
Nov. 7	9.2	2		20.4	12.4	32	0	92.5	38.2	7.5	45.2	38.1
Nov. 8	8.7	1		13.5		8	0	82.5	27.3	12.5	75.0	0.0
Total		7				112	63					

Many of the observations on behaviour and abundance made in 1987 were confirmed in 1988. However, additional and important observations were made. During windy weather when it was impossible to net on the exposed bar, it was possible on some occasions to net in the sheltered embayments of Main Duck Island in the vicinity of Yorkshire Bar (Table 10). It was observed that aggregations of smaller, younger, mature lake trout congregate in other areas along the more sheltered embayments on Main Duck Island. Ripe males were observed cleaning rubble at the mouth of the harbour on Main Duck Island. The concentration of lake trout in these areas was only about half that observed on Yorkshire Bar (Tables 9 and 10). During 1988, 128 lake trout were tagged, and 4 fish were recaptured, one previously tagged in 1987. There is reason to believe from the gillnet catch statistics and few tag returns that possibly a thousand lake trout frequented the bar at spawning time and possibly half that many congregated in groups on the edge of the adjacent embayments on the north side of Yorkshire and Main Duck islands. There is evidence that during heavy gale-force winds the lake trout moved off the edge of the bar and into deeper water (>6 m) and also into the protected shoreline adjacent to the bar, and then back onto the shallower water of the bar (3-5 m) when the weather calmed.

TABLE 10. Main Duck Island embayments in the vicinity of Yorkshire Bar lake trout spawning study 1988. Catch per unit effort expressed as numbers caught per 100 m² of gillnets. Gillnet sets were composed of two panels each 50 ft (15.24 m) x 8 ft (2.44 m) made of green monofilament, one 2.5- (63.5-mm) and one 3.0-inch (76.2-mm) mesh. Nets were set at dusk for 1 to 2 hours, with catches adjusted to 2 to 3 hours duration to provide comparable results to 1987.

			CUE at depth (m)			No. of lake trout		Percent males		Percent females		
Date	Water temperature at 5 m	No. of net sets	2	3	4	caught	tagged	total	ripe and running (rank >5)	total	ripe and running	spent
Oct. 21	12.4	3	21.53			24	19	90.5	6.7	9.5	8.3	0.0
Oct. 30	9.5	4		19.51		30	27	81.7	41.9	18.3	12.5	0.0
Nov. 1	9.4	4	14.80	32.28	2.75	24	19	79.2	41.7	20.8	54.2	0.0
Total		11				78	65					

In the autumn of 1988, 312 lake trout were captured on Yorkshire Bar and in its vicinity. The aggregations of mature lake trout on the bar were more concentrated and the fish were slightly larger in 1988 than in 1987. However, when the bar was netted with experimental gillnets in a fashion comparable to previous years, the overall relative abundance was somewhat lower than in 1987 (Table 11), but this was still 2.3 times greater than in 1984, when mature lake trout were observed in substantial numbers on Yorkshire Bar.

TABLE 11. Lake trout catch statistics for 12 years (1975-88) for gillnets set at spawning time on Yorkshire Bar of Yorkshire Island and for standard Lake Ontario experimental gillnets set at 26 to 38 m deep at six stations throughout the outlet basin (Kingston Basin) in the east end of Lake Ontario. Catches are expressed as number and weight of lake trout talem on 100 m² of net in 24 hours. The catches in the 2.5 and 3.0 mesh panels are expressed in the same units. The 1987 and 1988 netting was conducted with a slightly different type of experimental green monofilament gillnet (see Table 9).

	Yorkshire Bar spawning period						Outlet basin June-August		
	2.5-inch and 3.0-inch mesh			1.5 to 6.0-inch mesh experimental gillnet			1.5 to 6.0-inch mesh experimental gillnet		
	CUE			CUE			CUE		
Year	N	kg	Average wt (kg)	N	kg	Average wt (kg)	N	kg	Average wt (kg)
1975	0.00	0.00		0.40	0.06	1.508	0.22	0.21	0.966
1976	0.00	0.00		0.00	0.00		0.22	0.24	1.106
1977	0.28	0.47	1.68	0.47	0.78	1.646	0.41	0.35	0.857
1978	0.75	1.02	1.36	0.54	0.70	1.294	0.76	0.71	0.932
1979	0.30	0.47	1.55	0.36	0.73	2.048	0.94	1.32	1.402
1980	0.30	0.49	1.64	0.60	1.34	2.248	2.74	2.86	1.044
1981	1.39	2.42	1.74	1.21	2.95	2.426	1.77	2.27	1.279
1982	1.80	3.04	1.69	1.79	3.57	1.994	2.59	2.99	1.154
1983	4.19	9.60	2.29	4.96	12.30	2.481	4.19	6.04	1.442[a]
1984	16.73	42.49	2.54	19.84	52.11	2.626	5.38	10.38	1.929[a]
1985							6.73	13.88	2.062
1986							5.26	10.42	1.980
1987	[78.23	216.38	2.766][b]	[60.55	176.32	2.912][c]	10.49	21.59	2.059
1988	[137.20	389.00	2.835][b]	46.22	131.68	2.849[d]	6.32	13.62	2.156

[a] Estimated catch.

[b] Catch data for 2.5 and 3.0-inch mesh combined and adjusted for activity on spawning grounds to approximate the CUE for a 24-hour period to make the results generally comparable to other years.

[c] Estimated catch calculated from previous catch relationship between 2.5-inch and 3.0-inch mesh and 1.5 to 6.0-inch mesh experimental gillnet sets on Yorkshire Bar, since only 2.5-inch and 3.0-inch mesh gillnets were used in 1987.

[d] Catch data for 1.5- to 5-inch mesh, green monofilament, experimental gillnets set for 3 to 6 hours, and adjusted for activity on the spawning grounds to approximate the CUE for a 12-hour period to make the results generally comparable to other years.

One of the major problems that has developed in this study involves the inability to determine the age of most of the live hatchery fish that are handled. As reported in 1987, the procedure of using a single external mark (adipose clip) accentuates the problem. It is recommended that the procedure of applying a distinctly different external clip be resumed, along with the coded wire nose tag so that better age information can be determined without killing the lake trout in such spawning studies. In order to obtain more thorough biological information and age data, some of these mature fish were sacrificed in 1988. A sample of these fish was analyzed at the Fish Health Laboratory at the University of Guelph for fish pathogens that might prevent their eggs and progeny from being reared in the Ontario Ministry of Natural Resources fish culture system. These fish were all classified as completely disease-free.

Eggs were collected and artificially fertilized as part of a joint Great Lakes study organized by R. Eschenroder and the Great Lakes Fishery Commission to examine their survival and development in incubators. The specific details of this project are available, and will be presented elsewhere. However, the fertilization rate of the eggs was high, and although it was not possible, because of weather conditions, to bury incubators in the substrate of Yorkshire Bar, they were buried in spawning rubble in the west end of Lake Ontario. Some of these eggs and fry are at present being reared at the GLFC laboratory in Ann Arbor, and some incubators with Lake Ontario eggs are buried in artificial substrate used by spawning lake trout in Lake Superior.

On one occasion, egg traps, which were obtained from E. Marsden, were set on chains across Yorkshire Bar at fixed-depth intervals. The traps were set at dusk, and it was planned to life them several hours later that evening. However, the wind increased such that it was too dangerous to return to the bar for several days. No eggs were taken in these traps, although they were set across the section of the bar that was most actively frequented by the lake trout. However, it was generally concluded by the sampling crew that the traps had not been very successful. The netting on some was heavily frayed, and many in the shallower water (3 m) were untied and filled with coarse beach gravel.

Because of the frequent and severe winds and weather conditions encountered in 1987 and 1988 on the east end of Lake Ontario at spawning time, the design of this research will be carefully re-examined.

B. Project - Studies of nursery habitat of fry and juvenile lake trout

OBJECTIVES

Young juvenile lake trout are not sampled very efficiently in most routine sampling studies. This is because juvenile lake trout in naturally sustained lake trout populations are never very abundant; they are usually found in very deep water and appear to be relatively inactive, therefore not very vulnerable to passive gear. The nursery habitat of young lake trout after hatch, and up to approximately four years of age, is very deep. In midsummer it is well below the thermocline and the natural depth distribution of most adult lake trout. In a series of studies in inland lakes, it has been shown that in midsummer these young juvenile lake trout are found at 38 +/- 11.4 m (mean +/- 95% C.I.). It is apparent from the published literature that young lake trout in the Great Lakes are found in a similar deepwater nursery refugium. Their midsummer vertical distribution is, however, much deeper than in inland lakes (62 +/- 12.17 m--Table 12).

TABLE 12. Midsummer depth distribution (m) of lake trout in the Great Lakes. Data from published literature. In most cases lake trout are of hatchery origin.

	Juveniles		Adults	
Great Lake	Range	Median	Range	Median
Superior	37-62	50	18-26	22
Michigan	37-72	55	25-30	28
	50-90	71	20-40	30
Huron (Georgian Bay)	82-128	105	37-46	42
Ontario	25-40	33	20-30	25
Mean		62.8		29.4
95% C.I.		12.17		9.76

PROGRESS

The specific objectives of the study were (1) to sample lake trout and associated prey and predator species with depth (10-m intervals) in an area that is potentially deep enough to contain midsummer nursery habitat; (2) to sample potential nursery habitats of lake trout in the vicinity of spawning areas, especially Yorkshire Bar, in the east end of Lake Ontario to determine if juvenile and possibly indigenous lake trout are present; (3) to examine environmental conditions at these depths; (4) to determine if any of the young unmarked lake trout that are taken are indigenous.

Bottom set, fine mesh, monofilament gillnets ranging in mesh size from 0.5, 0.75, 1 to 5 inches in 50-ft (15.24-m) panels were set at approximately 10-m depth intervals southeast of Yorkshire Island in early August 1988. Replicate nets (3-5) were set at each of the following depths: 10.4 m, 23.4 m, 31.1 m, 42.0 m, and 54.0 m. Three half-mile tows of a bottom trawl were made at each of these stations. Large numbers of fish were caught, and with considerable consistency; up to 14 different species were taken. The vertical distribution and abundance of these species and the variance among the samples are being analyzed in relation to the distribution of the lake trout. More detailed analyses of the predator-prey associations will be conducted when more sampling has been done. However, the following observations may be of general interest.

There was a significant inverse relationship between the size of lake trout and the midsummer depth at which it was caught:

$$\text{Depth (m)} = 46.13 - 0.0169 \quad \text{FL (mm)}$$
$$N = 263 \qquad R = 0.385$$

This relationship applies over the depth range of 30 to 50 m and agrees with previous observations, and indicates that deep water (>40 m) must be sampled if indigenous, juvenile lake trout are to be found in numbers. These depths probably should be sampled in close proximity to spawning areas. Of the sample of 267 lake trout taken in this study, 12 (4.5%) were classified as having no external clip or hatchery mark. The fins, otoliths, and scales of these "unmarked" lake trout were analyzed in detail, using criteria developed for separating lake trout of hatchery and native origin (Casselman, unpublished data). Using these criteria, none of these unmarked lake trout were classified as indigenous. There are anomalous characteristics in the otoliths of some hatchery lake trout that are definitive. Seven (58%) of the twelve lake trout in this sample had otoliths that showed these definitive characteristics. In addition, four (33.3%) had coded wire tags in their snouts, even though their adipose fin had been classified as normal.

In the future, sampling effort will be increased in the deeper parts of the St. Lawrence trench, and at much deeper depths in the eastern basin of Lake Ontario southwest of Yorkshire Island in an attempt to sample more intensively the lake trout nursery habitat to try to locate, and determine the abundance of, young indigenous fish.